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ABSTRACT

This study examined quantitatively the effects of varying retention intervals (RI) within a 4 X 4 block schedule on knowledge retention of Algebra 2 skills and concepts. Specifically, the study contrasted the mean scores of students having an RI of 0, 8, and 12 months on a pre-review, post-review, and end-of-course test in precalculus. The study also examined qualitatively the instructional strategies used by teachers to eliminate the effects of the retention interval for all students beginning a new course of mathematics study. This study was conducted in two suburban high schools with at least 4 years of experience using a 4 X 4 block schedule. The sample for the quantitative component included all students, honors and merit, enrolled in precalculus. The sample for the qualitative component included precalculus teachers in both high schools. Initially on the pre-review test (multiple choice component), the mean score of students with an RI of 0 months was significantly higher than that of those with an RI of 8 or 12 months. Following a four-week review period, there was a significant difference in mean scores between students with an RI of zero months and 12 months. On the pre-review and post-review (performance-based assessment) there was no significant difference among the groups of students by RI. Notably, by the end course in precalculus, a final test administered to all three groups showed no significant difference among the students by RI on either the multiple choice or the performance-based assessment. In examining RI effects by different ability levels, there was no significant difference in the mean scores for precalculus merit students on the measure used as was also noted for all students regardless of ability. The same was true for precalculus honors students. Instructional strategies employed by teachers in reviewing Algebra 2 skills and concepts were the same as those associated with a traditional high school schedule. Contains 90 references. (Author)

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THE EFFECTS OF VARYING RETENTION INTERVALS WITHIN A BLOCK SCHEDULE ON KNOWLEDGE RETENTION IN MATHEMATICS

by

Brenda P. Shockey

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland at College Park in partial fulfillment
of the requirements of the degree of
Doctor of Philosophy
1997

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ABSTRACT

Title of Dissertation: THE EFFECTS OF VARYING RETENTION INTERVALS WITHIN A BLOCK SCHEDULE ON KNOWLEDGE RETENTION IN MATHEMATICS

Brenda P. Shockey, Doctor of Philosophy, 1997

Dissertation directed by: Dr. Ernestine Enomoto, Assistant Professor
Education Policy, Planning, and Administration

This study examined quantitatively the effects of varying retention intervals (RI) within a 4 X 4 block schedule on knowledge retention of Algebra 2 skills/concepts. Specifically, the study contrasted the mean scores of students having an RI of zero, eight, and 12 months on a pre-review, post-review, and end-of-course test in precalculus. The study also examined qualitatively the instructional strategies used by teachers to eliminate the effects of the retention interval for all students beginning a new course of mathematics study.

The study was conducted in two suburban high schools with at least four years of experience using a 4 X 4 block schedule. The sample for the quantitative component included all students, honors and merit, enrolled in precalculus. The sample for the qualitative component included precalculus teachers in both high schools.

Conclusions:

1. Initially, on the pre-review test (multiple choice component), the mean score of students with an RI of zero months was significantly higher

than that of those with an RI of eight months and those with an RI of 12 months. Following a four-week review period, there was a significant difference in mean scores between students with an RI of zero months and 12 months.

2. On the pre-review and post-review (performance-based assessment), there was no significant difference among the groups of students by RI.
3. Notably, by the end of course in precalculus, a final test administered to all three groups showed no significant difference among the students by RI on either the multiple choice or the performance-based assessment.
4. In examining RI effects by different ability levels, there was no significant difference in the mean scores for precalculus merit students on the measures used, as was also noted for all students regardless of ability. The same was true for precalculus honors students.
5. Instructional strategies employed by teachers in reviewing Algebra 2 skills/concepts were those associated with a traditional high school schedule.

DEDICATION

This work is dedicated to the memory of my late husband, Jack Shockey, who encouraged me initially to pursue a doctoral degree, and to my late father, Fred Stewart, who instilled in all of his ten children the belief that if something is worth doing, it is worth doing excellently.

ACKNOWLEDGEMENTS

I wish to gratefully acknowledge the contributions of many individuals who provided guidance, assistance, and support for this study.

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CHAPTER I

INTRODUCTION TO THE STUDY

Introduction

In the past five years, the utilization of time in many school schedules has been restructured by increasing the length of class periods in minutes and by reducing the number of class periods in the school day. One model that developed from this restructuring is commonly called a 4 X 4 block schedule (four class periods per day of approximately 90 minutes each for one semester -- a four-period day). The block schedule is popular among many students, teachers, school administrators, and parents. However, studies and reports of the effect of block schedules on achievement show contradictory results. Educators and parents question the effect of block schedules on knowledge retention when courses are taken for a semester (18 weeks) and when students have a lapse of one or more semesters between courses covering the same subject. This question is especially prevalent for mathematics when students have longer periods of time than the traditional three month summer break between mathematics courses. This study examined the effect of restructuring the utilization of time in a school schedule to a 4 X 4 block schedule on knowledge retention of mathematics skills/concepts.

Time has long been a primary interest of educators, specifically its utilization and impact on learning. As early as 1932, a study by Denman and Kirby showed the "relative efficiency of long and short class periods as indicated by pupils' scores on objective tests in several subjects in the high school curriculum" (Denman & Kirby, 1933, p. 284). Students with longer class periods (55 to 60 minutes) scored significantly higher on test measurements than did students with a shorter class period (40 to 45 minutes). As a result of this study, the North Central Association of Colleges and Secondary Schools, a regional accrediting association of the Commission on Secondary Schools for public high schools in the United States, set a standard of 45 to 60 minutes as a requirement for membership in its organization.*

For over 70 years, credit for courses taken at the high school level has been dispersed in Carnegie units, a system that equates learning with time in class (Carroll, 1990). The Carnegie unit became the standard measure in American education (Glickman, 1991). Secondary school requirements were universally based on this measurement with class periods of approximately 45 to 50 minutes for 180 school days. (National Education Commission on Time and Learning, 1994). For instance, graduation requirements in Maryland are designated by Carnegie units of credit, and Carnegie units are a requirement of public high schools for accreditation by the MSA (Commission on Secondary Schools, Middle States Association, 1972).

Although the Carnegie unit remains the system for awarding credit for high school courses, changes are emerging in the organization of the school schedule in an attempt to create a more effective and efficient utilization of the time available for learning (Fallon, 1995). As early as the late 1950s and early 1960s, changes in school schedules and the way schools were organized were being encouraged by groups such as the National Education Association and by Education Facilities Laboratories. The changes noted by Fallon (1995) were influenced by A Nation at Risk (National Commission on Excellence in Education, 1983). This report noted the utilization of time as an issue in today's public high school and recommended that the utilization of time available for learning be expanded through better classroom management and organization of the school day.

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* The regional accrediting association for public schools in the state where the study was conducted is the Middle States Association - MSA.

Likewise, numerous subsequent reports have recommended that the utilization of time in school schedules be restructured. Sizer (1984) criticized the public school schedule as a series of units where time is "king," with each unit existing as a time block of approximately 50 minutes in length. The National Education Association (NEA) (1994) criticized the traditional school schedule as so rigid that it was the constant thing on which we could depend in today's public high school instead of learning. The NEA argued that the utilization of time in a school schedule be flexible to best meet the learning needs of students. Time issues were addressed also in reports of the National Education Commission on Time and Learning (1993, 1994). Even though the relationship between time for learning and achievement was found over 60 years ago, the structure of the utilization of time in public schools has been virtually unchanged. In one of the reports by the National Commission on Time and Learning, Prisoners of Time (1994), the utilization of time was identified as the "missing element in our great national debate about learning and the need for higher standards for all students" (p. 4).

One of the most rapidly growing trends for restructuring the utilization of time in public high schools is the block schedule. Sommerfield (1996) calls it the "hot topic" in school reform, as it replaces the traditional schedule of six or seven, 45 to 50 minute classes per day with fewer classes that last longer. Cawelti (1995) lists block schedules as one of seven critical elements of restructuring. The block schedule, also known as the immersion model, intensive schedule, four-block, 4 X 4, and semester block, follows two basic approaches: (1) holding fewer classes per day that meet every other day for a full year (A/B day schedule) or (2) scheduling fewer classes per term and more terms per year. The second approach most commonly involves four blocks of time per day for one semester, a four-period day (Kadel, 1994).

Approximately 11% of the nation's high schools were using a block schedule in 1994 (Cawelti, 1994). This percentage increased to 14% in 1995 (Sommerfield, 1996). With the opening of the 1996-97 school year, more than 40% of the high schools nationwide were doing some form of a block schedule, considered to be one of the most successful restructuring initiatives in America today (Lammel, 1996). Citing Canady, Winans (1997) reported that as many as 50% of high schools were "now in or studying block schedules." According to Lammel (1996), educators realized that the traditional schedule became ineffective in meeting the academic needs of students.

> The need for a change in the school schedule becomes apparent when educators begin to identify the frailties of the traditional schedule. Asking professional teachers to deliver the curriculum, motivate, and assess 120 -180 adolescent students at a time is ludicrous. Possibly as ludicrous is the notion that a typical student can manage 6 to 8 different courses and adults every day from September to June. (Lammel, 1996, p. 5)

According to Lammel, the alternative was to restructure the utilization of time in the school's schedule to better accommodate teachers and students in an effort to create a more positive academic environment, improve student and teacher behavior, and ultimately affect student achievement.

An actual restructuring of the utilization of time during the school day began to receive widespread attention with the introduction of the Copernican Plan in the Masconomet Regional High School District, Massachusetts, in the early 1990s. This plan was a first attempt to abandon the traditional school schedule by creating longer class periods and fewer class periods per day. Laying the groundwork for the development of the block schedule, the Copernican Plan proposed major restructuring of virtually all the basic systems within a high school. But its fundamental change was in the school schedule, from the traditional model to a schedule with classes meeting for longer blocks of time. Instead of having students change locations, subjects, and activities seven to nine times a day, students involved in the Copernican Plan were asked to concentrate on one or two subjects at a time, each taught in an extended macroclass to be completed in part of the school year, a trimester (Carroll, 1990). The results of a study done after two years of the Copernican Plan showed students, teachers, and parents preferring the new school schedule over the traditional schedule. Classroom observations showed teachers using more innovations in the instructional pedagogy. However, the academic performance of students on the Copernican Plan was equivalent to the academic performance of students in the traditional schedule. Because of public dissent and problems among staff members, the Copernican Plan was abolished after two years.

Prior to the Copernican Plan, most high schools in the country had not changed a great deal in the past 30 years in terms of the organization of the school day. According to Scroggins and Karr-Kidwell (1995), "American schools stand at a crossroads; either continuing along the same path with its inherent and growing problems, or moving in a new direction that will result in real change and restructured schools" (p. 211). Scroggins and Karr-Kidwell contend that the conditions of today's schools require changes that will meet the needs and demands of today's student and society. These changes will include the abandonment of the traditional school schedule and the implementation of a block schedule which allow longer class periods of time for learning.

The adoption of a block schedule raises questions about its effectiveness for student achievement. A key issue of the 4 X 4 block schedule of four 90-minute class periods per day for one semester is its effect on students' knowledge retention since a year or more may elapse between courses of the same subject, thus interrupting the traditional sequence of courses (Carroll, 1990; Kramer, 1997). Many critics believe that the curriculum can not be covered and that students will forget too much if they are out of a subject for more than a three-month summer vacation (Carroll, 1994). This concern is especially prevalent for students' knowledge retention of mathematics skills/concepts (Canady & Rettig, 1995; O'Harrow & Bates, 1996; Willis, 1993).

Background of the Study

In the school district in which this study was conducted, a 4 X 4 schedule was first implemented in one of the eight high schools five years prior to this study (1991). In the following school year, three additional high schools in the district implemented a block schedule. These schools were followed by three high schools the next year, and one the next. Currently, all eight high schools in the school district use a block schedule.

In the school district where this study was conducted, block schedules involve the following arrangement:

- Students concentrate on four subjects at a time instead of seven.
- Students take 90-minute classes, four each semester.
- Students can earn eight Carnegie units a year toward graduation, instead of seven.
- Students transition in the halls five times a day instead of nine.
- Teachers teach approximately 80 students each semester.
- Teachers have 90 minutes of planning time each day instead of 45 minutes. (Meadows, 1995, p. 7)

Throughout the implementation of the block schedule in the school district of this study, the most commonly asked questions from parents focused on the knowledge retention of mathematics skills/concepts. Commonly asked questions were: "What about math?" "How will students do in their next math course if they skip one or more semesters between the two courses?" "Will they forget too much to do well in their next math course?"

The Purpose of the Study

The purpose of this study was to examine the effect of the block schedule on knowledge retention of mathematics skills/concepts, specifically Algebra 2 skills/ concepts, for students having a retention interval ranging from zero to 12 months. (Retention interval is defined in this study as the time period between the initial exposure to facts and concepts and the second exposure.) The study also examined the reacquisition of mathematics skills/concepts by the students after a period of review by the classroom teacher. Thirdly, the study examined the effect of a lengthened retention interval on achievement in the subsequent mathematics course, precalculus-honors or precalculus-merit. Finally, because students enter a mathematics course with varying retention intervals, the study examined qualitatively the strategies used by teachers to eliminate the effect of the retention interval for all students beginning a new course of mathematics study.

Although varying forms of block schedules have been used since the 1970s in some Canadian provinces and since the early 1990s in high schools in the United States, there is little empirical evidence supporting the advantages of block schedules compared to the traditional school schedule (O'Harrow & Bates, 1996; Sturgis, 1995). Most studies to date on block schedules are attitudinal surveys and lack a quantitative research base for determining what occurs in schools that have a block schedule in which courses last for only one semester (Brophy, 1978). Most studies report the advantages of block schedules to teachers and students, but information on the measures of accountability (test scores) is conspicuously sparse (Schroth & Dixon, 1995). The National Council for Teachers of Mathematics (NCTM) (1996) recently noted that more observational and anecdotal data exist than student performance data and that although schools report benefits to the school atmosphere and grades in general, reports of the effect on mathematics education are contradictory (News

Bulletin: NCTM, 1996). The NCTM noted that educators worry about students' ability to retain information when the gap between one mathematics course and the next one could be more than a year on a semester schedule. Fallon (1995) noted a need for an experimental study using public high school students and measuring their achievement in a block schedule during the regular school year. Therefore, this research study provided empirical data and test score information relative to the research questions regarding students' knowledge retention of mathematics skills/concepts.

Research Design

Conceptual Framework

This research study developed after a review of literature on block schedules and previous studies on cognition and knowledge retention. Although the literature cites many advantages of the block schedule to students, teachers, and schools, a recurring question was the effect of block schedules on knowledge retention.

A block schedule of approximately 90-minute class periods for one semester (90 days) created a scheduling model in which teachers were assigned approximately one-half the number of students for a semester that they had in a traditional school schedule of 45 to 50 minute class periods for 180 days (2 semesters). Likewise, teachers were assigned to teach a maximum of three, 90-minute class periods per day, again, one-half the number of class sections they taught in a traditional schedule. Although the number of students and class sections were reduced by half of what they were in a traditional schedule, the amount of time and total number of students taught in a school year remained the same (30 students X 3 sections for 90 minutes for 90 days = 30 students X 6 sections for 45 minutes for 180 days). Similarly, students in a block schedule had one-half the number of courses and teachers they had in a traditional schedule during a semester (18 weeks). The 4 X 4 block schedule model, with courses being only a semester duration, required some students to "skip" semesters between courses of the same subject. In the traditional schedule, the maximum time lapse in instruction (retention interval) between courses of the same subject was three months, a traditional summer break. A key consequence of the 4 X 4 block schedule, relative to achievement, was a possible effect on knowledge retention since students may have had a retention interval of zero to 12 months between courses of the same subject. This was in contrast to the traditional retention interval of three months caused by a summer break. The retention interval was determined by two factors:

- the enrollment of a student into only one course of the same subject during the school year, and
- the structuring of the school schedule and assignment of students to classes with a computerized scheduling system.

In schools using a 4 X 4 block schedule, students were encouraged to take no more than two major core subjects (mathematics, science, English, or social studies) within one semester and only one course of a particular subject during a school year.

Of particular interest to educators and parents is the effect of the 4 X 4 block schedule on knowledge retention in mathematics. Because of the sequential nature of the skill/concept development in mathematics, educators and parents questioned the effect on mathematics achievement of a retention interval longer than the traditional summer break. Spitzer (1939) and Musser (1983) noted that knowledge retention is important because the improvement of skills and knowledge is dependent upon the learner's retention of previously learned skills and knowledge. As for other courses of the same subject, students in mathematics courses were generally encouraged to take only one mathematics course per school year. This approach prevented students from completing their mathematics requirements too soon in their high school program.

Because courses were only one semester in length, students could have conceivably finished the three mathematics courses required for graduation by mid-year of the sophomore year of high school. Therefore, an early completion of mathematics courses may possibly have affected students in college admission testing and eventual performance, or in their career choices.

The results of studies on knowledge retention identified specific factors which influence it. A summary of these factors included the following:

- the organization of the material to be learned (Carroll, 1994).
- how well the original learning took place (Bahrick, 1984; Schuell and Giglio, 1973).
- the type of learning: recall, comprehension, or application (Bahrick, Bahrick, & Wittlinger, 1975; Bahrick, 1984; Conway, Cohen, & Stanhope, 1991; Semb, Ellis, & Araujo, 1993).
- the ability level of the student (Bahrick & Hall, 1991; Semb, Ellis, & Araujo, 1993; Silver, 1981).
- the time available for learning (Bahrick & Hall, 1991; National Education Commission on Time and Learning, 1994).

Proponents of block schedules contended that learning was enhanced by the longer class periods. Specifically, a summary of their assertions included the following:

- block schedules allowed for the content learned to be better organized in delivery and the increased time fostered assimilation, resulting in improved cognition. (Carroll, 1994).
- block schedules allowed for longer class periods which improved in-depth learning and opportunities for higher levels of thinking; comprehension, application, analysis, synthesis, and evaluation instead of an emphasis on recall (Kadel, 1994; Kramer, 1996; Kramer, 1997; Meadows, 1995; O'Harrow & Bates, 1996; Schoenstein, 1995; Sturgis, 1995).

- lower ability students performed better because of the decrease in the number of subjects on which they must concentrate in a semester of study (Hottenstein & Malatesta, 1993).

Opponents of block schedules argued that there were inadequate research studies to support the claims of the proponents of block schedules, especially the effect of block schedules on knowledge retention (Canady & Rettig, 1995; Carroll, 1990; Carroll, 1994; O'Harrow & Bates, 1996;Willis, 1993).

Research Questions

This research study was a combined quantitative and qualitative study. The quantitative study examined the effects of a 4 X 4 block schedule in two suburban high schools on the knowledge retention of mathematics skills/concepts, specifically Algebra 2. Based on classroom observations, the qualitative study identified and described the strategies used by teachers during review for students to reacquire mathematics skills/concepts. The study developed from the lack of statistical evidence in the literature that showed the effect of block schedules on knowledge retention of mathematics skills/concepts and qualitative data that describe instructional strategies used by classroom teachers with students in the reacquisition of mathematics skills/concepts.

More specifically, answers to the following questions were sought:

1. Is there a significant difference in scores on a pre-review test given at the beginning of a precalculus course among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
2. Is there a significant difference in scores on a post-review test given at the end of the teacher review of approximately four weeks among three

groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

3. Is there a significant difference in scores on an end-of-course test in precalculus among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months) before entering the precalculus course?
4. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
5. Is there a significant difference in the scores of precalculus-merit students on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
6. Is there a significant difference in the scores on an end-of-course test in precalculus among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
7. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
8. Is there a significant difference in the scores on a post-review test given at the end of the teacher review of approximately four weeks among

three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

9. Is there a significant difference in the scores on an end of-course test in precalculus among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

10. What instructional strategies are used by teachers to review Algebra 2 skills/concepts so that students can reacquire previously learned skills/concepts that may have been lost during the retention interval?

Research Methodology

This study was conducted in two high schools in a suburban school district located in the mid-Atlantic region of the United States. The two schools in the study were selected because both have been on a 4 X 4 block schedule for four and five years. Consequently teachers and students were experienced with instruction and assessment on a block schedule. Also, the demographics of the two schools were very similar. Each of the schools in the study operated under a four-period block schedule of 90-minute class periods lasting for one semester (90 days).

Both quantitative and qualitative methodologies were used in the study. Quantitative methods were used to answer the questions on the effect of the block schedule on knowledge retention of mathematics skills/concepts. A qualitative method was used to answer the research question on strategies used by teachers to review the skills/ concepts of the prerequisite mathematics course (Algebra 2) in order to decrease the effect of varying retention intervals for students.

Student scores on a multiple choice component of an end-of-course test in Algebra 2, consisting of 37 multiple choice items, were used as the baseline data for the retention study. On the first day of the subsequent mathematics course, precalculus, the same Algebra 2 end-of-course test was administered to students as a pre-review test. These scores were compared with the baseline scores to find if there was a retention loss and if the retention loss was greater for students with a longer retention interval. Additionally, one performance-based assessment, the second component of the end-of-course test in Algebra 2, was given to all student participants on the second day of the precalculus course. After the completion of the review of Algebra 2 skills/concepts by the four teachers in the study (approximately four weeks into the semester), both parts of the Algebra 2 end-of-course test were repeated as a post-review test. These scores were compared with the baseline scores to find if students had reacquired the skills/concepts, if forgotten, during the retention interval. The final segment of the quantitative study was a comparison of student scores on an end-of-course test in precalculus to find if the lengthened retention interval had an effect on student achievement in precalculus.

For the qualitative study, data were collected directly by the researcher during classroom observations. These data were compared to the research literature to identify what strategies teachers used to review skills/concepts with students having varying retention intervals and if these strategies were consistent with those reported in the literature for teachers using a block schedule. At the end of the observation period, meetings were held with the teacher participants to discuss strategies observed.

At the conclusion of the study, follow-up meetings with teachers and administrators of the two schools involved in the study were conducted to discuss the research findings and the implications of the findings for scheduling mathematics courses in a block schedule.

Significance of the Study

This study is significant for the following reasons:

1. Because of the perceived positive effect of block schedules on instruction and learning and on school climate, there is rapid implementation of the 4 X 4 block schedule in the school district of this study and in high schools across the nation. However, there is little formal research on block schedules in secondary schools. The research done has been primarily of a qualitative design, reporting more observational and anecdotal information than student performance data. A question often asked by educators considering a move to a block schedule is, "what research is there to support the change?" A superintendent in a large, suburban school district neighboring the one in which this study was conducted remarked, "We don't have any research in terms of student achievement," when explaining his reluctance to initiate more block schedules in his district (O'Harrow & Bates, 1996). This study will add significantly to the empirical research on block schedules.

2. A major concern of educators and parents, as noted in the literature, is knowledge retention, especially in mathematics, of students on a 4 X 4 block schedule of 90-minute class periods lasting for one semester. Shortt and Thayer (1995), citing survey data collected for four years, identified retention of information when students have a time gap between courses as one of great concern. Teachers fear a great loss of learning and see a problem when students who have recently finished a prerequisite course are mixed with those who may have completed the prerequisite a year earlier (Canady & Rettig, 1995). Albers (1972) investigated the effects of 110-minute class periods for 90 days on the knowledge retention of high school students in biology and geometry. He found that the allocated time did not significantly affect the retention

of what students had learned. Albers recommended that similar studies be done with extended blocks of instructional time and in other courses within the mathematics discipline, with differing student populations including high and low socioeconomic (SES) groups, different ability groups, and secondary school students at different levels of maturation. This study will examine the knowledge retention of Algebra 2 skills/concepts by students on a 90-minute block schedule for 90 days (one semester). The results of this study will add to similar studies of knowledge retention for students in two ability groups using a block schedule.

3. In a preliminary study by Guskey and Kifer (1995) of one of the high schools in this study, after one year of implementation of a block schedule, teachers reported they could discern little difference between the students who had just recently completed a prerequisite and other students with a greater time lapse between courses. This study will show whether there is a difference in knowledge retention of Algebra 2 skills/concepts after a retention interval of zero, 8 and 12 months.
4. Also, in the study, Guskey and Kifer (1995) reported that a longer time lapse than the three months of summer did not increase the need for review. This study will examine the reacquisition of knowledge for students, with varying retention intervals, after the teacher has completed the review of skills/concepts from a prerequisite course, specifically Algebra 2.
5. There are some quantitative data emerging that show mathematics achievement may be lower in schools using a block schedule. A comparison of students in North Carolina, in schools using block schedules, end-of-course test results in 1994 of blocked and unblocked

schools, showed scores in math to be lower in schools with block schedules. In Algebra 2 and geometry, scores were significantly lower (NCTM, 1996). Data emerging from Canadian schools where block schedules have been in use since the 1970s also indicated lower achievement in mathematics. This study will explore a possible connection between knowledge retention and mathematics achievement.

6. Bahrick and Hall (1991) cite as the most important predictor of the retention of information, the conditions of the original exposure to the knowledge. They contend that when content is acquired over a shorter period of time, knowledge retention tends to decline rapidly and continuously. This assertion is an argument against a block schedule of classes lasting only one semester. This study, by comparing knowledge retention loss at varying intervals, will add to the understanding of this claim.
7. Willis (1993) argues that as more and more teachers try instructional innovations that work best with longer blocks of time; cooperative learning, hands-on activities, long-term projects, and interdisciplinary lessons, they are finding the typical 50 minute class period to be a barrier. Through classroom observations, this study will show whether teachers using a 4 X 4 block schedule in mathematics are using these innovations.

Definition of Terms

The following terms were used in the study as they are defined below:

1. Retention is defined in this study as the capacity to recall, comprehend, or apply previously learned facts and concepts.

2. Retention interval is defined in this study as the time period between the initial exposure to facts and concepts and the second exposure.

3. Block schedule is defined as a schedule having four periods that are approximately 90 minutes in length, meeting for only one semester (90 days); commonly referred to as the 4 X 4 block schedule.

4. Traditional schedule is a school day schedule having seven periods that are each approximately 45 minutes in length, meeting for two semesters or 180 days.

5. End-of-Course Test is defined as a uniform, end-of-course test given to each student to determine the mastery in each mathematics course. These tests have a multiple choice and performance components.

6. Instructional level for the students is defined in this study as follows:

   (a) Honors instructional level typically connotes performance beyond one's grade level in a subject of one or more years.

   (b) Merit instructional level indicates performance at grade level in a subject.

Assumptions

The following assumptions are made in this study:

(1) Students performed to the best of their ability on all administrations of the test instruments.

(2) Teachers of precalculus use instructional strategies which enable students to reacquire the mathematics concepts/skills not retained during the retention interval.

(3) There is a measurable loss of knowledge during the retention interval.

(4) Some degree of objectivity will exist in the sample selection, variables being measured, and the design of the study.

(5) Inferences can be made from this sample to the population of mathematics students on a block schedule.

(6) Knowledge retention loss can be measured and quantified in the public school setting.

(7) Instructional practices/pedagogy appropriate for a block scheduled class period can be identified in a normal classroom setting.

Organization of the Dissertation

Chapter 1 introduces the study, states the purpose and significance of the study, and states the related research questions. It also includes the conceptual framework, how the study was conducted, definitions of terms as they are used in the study, and assumptions made for the study.

A comprehensive review of the literature pertaining to time issues related to restructuring schools, block schedules; history, benefits, concerns, and studies of knowledge retention, is included in Chapter 2.

Chapter 3 describes the quantitative and qualitative methods used in the study. Quantitative methods were used to examine the effect of the block schedule on student test scores on an end-of-course test after a retention interval of zero, eight, and 12 months. Qualitative methods were used to identify strategies observed during the review of previously learned mathematics skills/concepts during the first two to four weeks of the precalculus course.

The findings of this study as they relate to the research questions are reported and discussed in Chapter 4. These findings are presented in tables and summaries where appropriate.

Chapter 5 discusses the research questions, methodology, and findings from this research study. In addition, the chapter includes the conclusions and recommendations for further research.

CHAPTER II

A REVIEW OF THE LITERATURE

Introduction

This review of literature begins by examining the traditional organization of time in public schools and subsequent calls to change how the utilization of time is structured. The restructuring of the utilization of time is connected to the development of block schedules. The advantages of block schedules and their impact on achievement are discussed. The disadvantages of block schedules, as expressed in the concerns of educators and parents, are summarized. A review of the impact of the block schedule on mathematics achievement and knowledge retention is included, along with a lengthy review of research studies concerning knowledge retention.

Traditional Scheduling

Prior to the recent restructuring of the utilization of time, meeting the requirements for Carnegie units was the primary concern of those making decisions about the allocation of instructional time in high school schedules. The Carnegie unit, a system of equating learning with time in class, was implemented over 70 years ago (Carroll, 1990). The Carnegie unit evolved between 1893, with the establishment of the Committee of Ten, and 1907, when Henry Pritchard, President of the Carnegie Foundation for the Advancement of Teaching, defined it as 45 minutes per day for five days a week for the entire school year (Carroll, 1994). The Carnegie unit remained the basis for secondary school graduation requirements, representing one credit for completion of a one-year course, meeting daily (National Education Commission on Time and Learning, 1994). Glickman (1991) describes the Carnegie unit as nothing inherently sacred, but instead a convention invented primarily as a means of satisfying the interest of higher education in having a basis for judging college preparedness. As such, the Carnegie unit was the accepted standard of measure in education, just as the pound, quart, and inch were for weight, volume, and distance.

To allocate the seat time necessary to meet the requirements for the Carnegie unit, educators traditionally divide the school day into six or seven periods of time, lasting from 45 to 50 minutes. Sizer (1991) describes a typical high school student's day as one marked by rapid change of subjects. Usually the subjects are planned by the teacher without any relationship to any other subject, resulting in "intellectual chaos, with rushes of ideas, facts, and expected skills, with all changing classes every 45 to 47 minutes" (Sizer, 1991, p.3). In the traditional schedule of six to seven classes of 45 to 50 minutes each, students are required to "shift gears mentally" as they move from one class to the next, typically six times a day (Willis, 1993, p.2). In a study of four high schools in California, researchers studied 19 students in all their classes for two full weeks (1600 hours) (Eisner, 1988). The purpose of the study was to learn about the schools from the perspective of students and teachers who spend a major part of their time there. The study reported a

> structurally fragmented feature of schools where teaching is done in chunks of 50 minutes in length, for each subject, each subject assigned to a room and a teacher, and every 50 minutes the entire population of the school moves from one chunk to another. (Eisner, 1988, p. 24)

Sizer (1994) describes the chunks of time as a series of units where the clock is "king" (p. 79). Likewise, Cawelti (1994) criticizes the traditional six- or seven-period-day as one which involves frequent class changes resulting in a loss of time, multiple preparations for teachers, and little opportunities for interdisciplinary work.

In A Nation at Risk (National Commission on Excellence in Education, 1983), a call for a change in the organization of the school schedule was made. The report recommended that the school day be reorganized as a way to increase the time available for learning. Ten years later, another report from the National Education Commission on Time and Learning (1994, April) continued to criticize the traditional school schedule. This report noted that: "no matter how complex the subject -- literature, shop, physics, gym, or algebra -- the schedule assigns each an impartial national average of 51 minutes per class period, no matter how well or poorly students comprehend the material" (p. 7). Scroggins and Karr-Kidwell (1995) criticized the traditional six- or seven-period-a-day schedule as one which discourages in-depth study or analysis of a subject and higher level thinking activities. Perhaps the strongest criticism of the traditional school schedule comes from Prisoners of Time (National Education Commission, 1994). The report suggested that the traditional, six-hour school day and the 180-day school year "be relegated to museums as an exhibit of our education past" (p. 8). The report pointed out that the clock and calendar control American education.

> Schools typically open and close at the same time each day, class periods average 51 minutes nationally, no matter how complex the subject or how well prepared the students, schools devote 5.6 hours a day for 180 days to instruction of all kinds as they award high school diplomas on the basis of Carnegie units. (National Education Commission, 1994, p. 9)

Finally, the report asserted that the school clock governs how teachers work their way through the curriculum, how material is presented to students, and the opportunity students have to comprehend and master the material (National Education Commission, 1994). In Prisoners of Time, the Commission (1994) offered eight recommendations to the nation, two of which focused on time: (1) reinvent schools around learning, not time, and (2) use time in new and different ways.

In addition to national reports that recommend a change in the utilization of time, professional educational organizations and individuals made similar recommendations. At the annual convention of the National Association of Secondary School Principals, participants recommended providing students with continuous curriculum contact and doing this by considering longer blocks of learning (Keefe, 1992). Lammel (1996) supported a reorganization of the daily time schedule as a way to better accommodate teachers and students by creating a more positive academic environment, improving student/teacher behaviors, and ultimately affecting student achievement. Glasser, as cited in Scroggins and Karr-Kidwell (1995) maintained that it is time to get rid of the present educational model and to replace it with one that will better meet the needs of today's students. Scroggins and Karr-Kidwell (1995) proposed longer blocks of time in a single class to provide the time needed to extend students' thinking beyond lower-level cognitive activities. They argued that longer blocks of time will allow for in-depth discussion necessary for higher-order thinking skills.

Block Scheduling as An Alternative

To consider the recommendations for change in the way schools organize the utilization of time required some consideration of restructuring. The term "restructuring" has come into use to describe significant changes designed to contribute to greater productivity and effectiveness. Cawelti (1994) defined restructuring as "actions that involve fundamental changes in the expectations, content, and learning expectations through creative incentives, different organizational structure, new and improved instructional technologies, and broader collaboration with community agencies and parents" (p. 3).

Fallon (1995) described restructuring as a focus on fundamental changes in the expectations for student learning in the practice of teaching, and in the organization and management of public schools. Principals defined restructuring as a "strategy used to analyze and redesign the organization or structure of education in order to achieve improved outcomes, student learning and performance" (Keefe, 1992, p. 3). At the middle and high school level, restructuring the utilization of time has been the most popular approach to school restructuring (National Education Commission, 1994).

Goodlad (1984), in A Place Called School: Prospects for the Future, recommended many changes for school structure and organization. One of the recommendations he made was to reduce the hours of teaching to provide more planning time for teachers as well as for working with individual students. However, with the constraints of current school budgets, a question arose as to how to provide this time. This was one consideration given to block schedules as schools move to this structure, because the planning time for teachers was also 90 minutes in a block schedule, compared to 45 to 50 minutes in the traditional schedule.

Cawelti (1994) defined a block schedule as one in which at least part of the daily schedule is organized into larger blocks of time (more than 60 minutes) to allow flexibility for varied instructional activities, including the opportunity to work more individually with students or give all students more opportunity for interaction with the teacher. In a traditional 45-minute class period, with approximately 30 students per class, the teacher's time per student was a maximum of one and one-half minutes, whereas in a block schedule of 90-minute class periods and 30 students per class, the teacher's time per student was a maximum of three minutes.

Block schedules continue to be implemented as a means of school reform, with a growing number of schools replacing the traditional structure of six or seven 45-minute periods a day with fewer classes that last longer (Kadel, 1994; Sommerfield, 1996).

The current trend in block scheduling was an outgrowth of the Copernican Plan as implemented in the Masconomet Regional High School District (Massachusetts) in 1990 (Carroll, 1990; Carroll, 1994). In the Copernican Plan, classes were taught in much larger periods (90 minutes, two hours, or four hours per day) and met only part of the school year (30 days, 45 days, 60 days, 90 days). Students were enrolled in significantly fewer classes each day and teachers dealt with significantly fewer students and classes each day (Carroll, 1994).

> The Copernican Plan was predicated on the assumption that, if the schedule for students and teachers was completely reoriented to provide better conditions that will accommodate better instructional practices, then many practices identified with more effective instruction could be implemented. (Carroll, 1990, p. 361)

Block schedules and variations of them are known by many names: immersion model, intensive education, intensive schedule, alternative scheduling, four-block, four by four (4 X 4), four-period day, and semester block (Lammel, 1996; Schoenstein, 1996). Regardless of what name is given to the reorganization of time in schools, the "idea is clearly one of the fastest growing and most successful restructuring initiatives in America today" (Lammel, 1996). Although a reorganization of the utilization of time is recommended in A Nation at Risk (National Commission on Excellence in Education, 1983), the use of a block schedule in public high schools was not recommended in a national government report until the report by the National Education Commission (1994). This report noted that "the reform movement of the past decade is destined to flounder unless it is harnessed to more time for learning" (p. 4).

There are currently four variations in the organization of the use of time in a block schedule. The first variation is a four-period trimester system. In this schedule, courses meet for three 12-week terms with four courses, each meeting 80 minutes a day. Previously full-year courses may meet for two trimesters and not always consecutively (Canady & Rettig, 1996; Cushman, 1996; Winans, 1997). A second variation is the 4 X 4 schedule, in which students take four 90-minute classes a day and complete them in a semester rather than in a full year (Canady & Rettig, 1996; Cushman, 1966; Edwards, 1995; Winans, 1997). A third variation is the A/B schedule. In this schedule, students take eight 90-minute classes for a full year, but the classes meet every other day, four on day "A" and four on day "B." In this schedule there are no long time breaks between courses in a sequence (Canady & Rettig, 1996; Cushman, 1966; Sommerfield, 1996; Winans, 1997). The fourth variation is the 75-15, 75-15 schedule where students take four classes for a 75-day fall term, followed by a 15-day intersession. The pattern is repeated in the spring term (Canady & Rettig, 1996; Lammel, 1996; Sommerfield, 1996; Teacher Magazine, 1996; Winans, 1997). More schools are experimenting with this schedule, because it allows 15 days for enrichment activities, remedial work, school to work programs, community service, and field trips.

Of these variations, the 4 X 4 semester block schedule is currently the most popular and successful (Kramer, 1997; Lammel, 1996). This variation allows students to accumulate the credits (Carnegie units) they need for graduation through four periods of 90-minute duration every day for 90 days (Cawelti, 1994). The 4 X 4 semester block schedule is the variation examined in this research study.

In theory, block schedules carve out more available time for instruction by reducing the amount of time students spend walking from class to class. Block schedules also reduce the time a teacher spends taking attendance or getting a class to settle down and concentrate on the day's lesson (Fraley, 1997; Kramer, 1996; Sommerfield, 1996). According to Lammel (1996),

> once a block schedule is in place, it will act as a catalyst to overall school improvement; better grades, more learning, improved academic environment, less stress, fewer discipline problems, more focus, and less

> diversion and will produce a stronger academic program that may ultimately affect student achievement in a positive way. (p. 5)

Advantages of Block Schedules

Advantages for Instruction

Advocates of block schedules list many advantages of this structure for the utilization of time. Of particular importance is the effect of block schedules on instruction. Block schedules are making us rethink how and what we teach, which forces schools to provide more in-depth learning (higher level thinking skills) instead of surface learning (recall of facts) (Kramer, 1996; O'Harrow & Bates, 1996). Kadel (1994) supports this claim and indicates that block schedules encourage the use of more effective instructional practices during the longer class period, thus resulting in more learning and higher achievement. The conclusions of a perception survey of the block schedule in four high schools in a large, suburban school district show that the four-period day block schedule affects how teachers teach. In a study of four high schools using the 4 X 4 block schedule, Meadows (1995) reports that teachers use a greater variety of learning activities, provide for eight to ten transitions during a class period, are more creative, plan more and for in-depth lessons, allow more opportunities for critical thinking and deeper discussion, and more integration of subjects. In a block schedule, teachers can venture away from lecture and discussion to more productive models of teaching (Canady & Rettig, 1993). In a review of the research on block schedules, Sturgis (1995) reports that the general consensus is that instruction involves more introduction of process and problem solving in the classroom. Cooperative learning, a strategy of instruction favored by many educators, is used more extensively by teachers using a 4 X 4 block schedule (Hottenstein & Malatesta, 1993; Sadowski, 1996; Winans, 1997). According to Downs (1997), cooperative learning is a technique that teachers can use to their advantage with longer periods. In addition to its influence on instruction and learning, cooperative learning changes the social dynamics of a class when students work together to solve problems. These findings are supported by the changes in instruction documented at Roy G. Wasson, Colorado Springs, Colorado. After the implementation of the 4 X 4 block schedule at this school,

> teachers moved away from "sage on the stage" and encouraged more student involvement and student-directed learning. The teachers stopped lecturing and started guiding students in cooperative learning, critical thinking, and problem-solving. New interdisciplinary and team taught classes emerged that stressed connections between separate subjects. (Schoenstein, 1995, p. 20)

Smith (1994) reports that intensified schedules, such as an A/ B day block schedule, facilitate hands-on learning, higher order thinking, cooperative learning strategies, and active participation. Many teachers in a block schedule believe their students understand concepts better because they are building on what they have learned in logical, sequential steps (Sadowski, 1996).

Advantages for Teachers

One great advantage of a 4 X 4 block schedule for teachers is the reduced number of students for whom the teacher is responsible per term (Canady & Rettig, 1996; Edwards, 1995; Kadel, 1994). Advocates claim that block schedules afford the opportunity for teachers to become knowledgeable about their students earlier in the school year. In a study by Brophy (1978) of two schools with courses lasting a full year and four schools with block scheduled classes of 60-80 minutes lasting only a semester, teachers were of the overwhelming opinion that they were well acquainted with both the personal and academic aspect of the students. When asked, "In general, how long does it take you to identify students who are having less difficulty?", a relative difference was found; 68% of the teachers in schools having semester long courses said it took two weeks, 70% of the teachers in schools having courses lasting a full year said it took them one month. In a 4 X 4 block schedule, teachers become more intimately involved on a daily basis with individual students (Buckman, King, & Ryan, 1995; Hottenstein & Malatesta, 1993; Winans, 1997). The decreased load of students makes it easier for teachers to individualize instruction and do more "one-on-one" instruction, which results in a better rapport between teacher and student (Willis, 1993).

Another advantage to teachers in a 4 X 4 block schedule is more planning time for fewer classes (Canady & Rettig, 1996; Edwards, 1995; Winans, 1997). On a 4 X 4 block schedule, teachers can prepare for just three classes a semester rather than the typical five to seven (Canady & Rettig, 1993; Kadel, 1994; Sturgis, 1995). Also, just as the length of a class period on a 4 X 4 block schedule is approximately 90 minutes, so is the planning time for teachers. This is twice the amount of planning time of 45-50 minutes on a traditional schedule (Kramer, 1996). A block schedule class allows teachers to concentrate their time and energies in a much more effective way (Willis, 1993).

Advantages for Students

As a block schedule allows for benefits for instruction for the teacher, it also allows for benefits of learning to the student. Block scheduled classes allow students to concentrate on fewer subjects and to study a subject in depth without interruption (Willis, 1993). Having fewer subjects per term gives students fewer classes for which to prepare each day and enables them to take more classes each year (Kadel, 1994; Kramer, 1996). Concentrating on fewer academic areas is especially helpful to the average and struggling student (Hottenstein & Malatesta, 1993). Another benefit is that students can move ahead more quickly and can take more courses of a particular subject in a calendar year (Canady & Rettig, 1993; Canady & Rettig, 1996; Edwards, 1995; Fraley, 1997; Grand, 1996; Kramer, 1996; Kramer, 1997; Sturgis, 1995). The block schedule also allows students to take more subjects than they ever took before since one additional course can be taken each year (Winans, 1997).

In addition to the direct advantages of a block schedule for instruction and learning, there are other advantages as well. Advocates of the block schedule note an improvement in the school climate (Buckman, King, & Ryan, 1995; Hackman, 1995; Johnson, 1996; Kramer, 1996; Kramer, 1997; Reid, 1995; Schoenstein, 1995). The "hectic" pace slows and the stress level is reduced for students and staff (Schoenstein, 1995). Coinciding with the improvement in the school climate is a decrease in the number of student discipline problems (Kramer, 1997). Meadows (1995) reports that student behavior and student attitude are affected by the 4 X 4 block schedule. In the first year at the high schools in her study, the referral rate dropped 18%. Teachers and administrators attribute the improved student behavior to fewer opportunities to get into trouble. In a block schedule, students spend less time in hallways, an area of a school where discipline problems frequently begin (Kramer, 1997). Carroll (1994) and Johnson (1996) attribute the better student behavior to improved interpersonal relationships made possible by longer class periods and less stress on students who have fewer classes a day.

An increase in attendance by students and teachers is noted by some schools on a block schedule (Fraley, 1997; Reid, 1995; Sturgis, 1995). At Roy G. Wasson High School, Colorado Springs, Colorado, over a five year period on a 4 X 4 block schedule, the attendance rate increased from 91.7% to 93.9% (Schoenstein, 1995). At Hatboro-Horsham High School in Pennsylvania, the attendance rate increased from 95.8% to 96.7% after one year on the 4 X 4 block schedule (Hottenstein & Malatesta, 1993). Buckman, King, and Ryan (1995) report an increase in attendance from 89.03 % to 91.26 % after one year on an A/B day block schedule. Smith (1994) reports an increase in attendance of 9.3% during the first year of an A/B day block schedule. Meadows (1995) does not report evidence of student attendance or drop-out rate being affected by a block schedule. Sharman (1990) does report that block schedules appear to lead to a reduced drop-out rate. Generally, schools using a block schedule report lower dropout rates (Kramer, 1997).

Block schedules continue to gain favor with students, teachers, and parents. Reid (1995) reports that block schedules have strong support from a majority of students and parents. Meadows (1995) reports that teachers (83.9%), students (66.7%), and administrators (100%) prefer a 4 X 4 block schedule to the traditional schedule. Citing Canady, Sadowski (1996) reports that after the first year or two, about 80% of the students and teachers say they prefer the block schedule and would not want to go back to shorter periods.

Effect on Student Achievement

As noted earlier, secondary school principals name improved student performance as the goal of restructuring. The literature is contradictory as to the effect of block schedules on student performance. So far, there is only a small body of research on whether a block schedule helps students learn more (Sommerfield, 1996). Fallon (1995) notes that proponents of block schedules assume certain relationships between variables. One of them is "the processes made possible by the conditions created by intensive education provide opportunities for increases in student achievement" (p. 8). Hart (1994) suggests that the adoption of a 4 X 4 block schedule has a considerable effect on student and teacher behavior, indicating improved teaching and learning. However, what evidence is available to support this claim made by Fallon and Hart?

Improved student achievement is reported for Roy G. Wasson High School (Schoenstein, 1996). After four years on a 4 X 4 block schedule, the number of student scores of four or five on Advanced Placement Tests increased from 26% of those taking the test to 37% (27 weeks of 90-minute classes; 12,150 minutes of instruction compared to 8,100 minutes on the traditional schedule). The number of students on the honor roll increased from 20.8% to 26.5%, and the number of credits earned per year increased from 4.8 to 5.8 credits (Schoenstein, 1996). After five years, the course failure rate dropped from 31% to 25%. However, the average ACT score dropped from 20.1 to 20.0 (Sadowski, 1996; Schoenstein, 1995). In that Schoenstein was reporting the data for the total school population who had taken the ACT over a five year period, this one-tenth percent drop can be considered as significant. However, Schoenstein suggests that a change in the school's demographics may also be making an impact on the decline in ACT scores.

Hottenstein and Malatesta (1993) report similar results in achievement at Hatboro-Horsham High School. After one year on the 4 X 4 block schedule, the number of students on the honor roll increased from 244 to 534. The failure rate on final exams decreased from 34% to 24%, and only one senior did not graduate, compared to 10 to 15 in previous years. Smith (1994) reports an increase of students on the honor roll from 113 in 1992-93 when the school was on a traditional schedule to 151 after the first year of implementation of an A/B block schedule.

Fraley (1997) reports that after two years on a 4 X 4 block schedule, Williamsport High School had its highest achievement ever on Maryland Functional Tests in reading, mathematics, and writing. Winans (1997) reports that at Asheboro High School in North Carolina, the block schedule had an impact on college preparation. In 1991-92, only 64% of Asheboro graduates qualified for entrance to the University of North Carolina system. By 1994-95 this percentage increased to 82%.

Fallon (1995) describes a study by Baylis (1985) in which a pretest-posttest control group design was used to collect data for the analysis of the comparative effects on student performance on seventeen specific learning behaviors. The study showed a statistically significant advantage to the experimental group on a block schedule of one class of four hours for 30 days. The grade point average (GPA) of the experimental group was higher but there was no significant difference between the groups on the Iowa Basic Reading posttest. Fallon also referenced a study by Munroe (1989) in which the improvement of the GPA of students in an experimental group on a 4 X 4 block schedule was greater than the traditionally scheduled group.

While there is evidence supporting improved student performance on a block schedule, there is also evidence to the contrary. A study conducted by Bateson (1990) shows that students on a traditional schedule in British Columbia schools outperformed students in two block scheduled schools on national math and science exams for tenth grade students. Another Canadian study based on ninth grade reading scores of 30,000 students reports that the block schedule has no impact on achievement. Likewise, a 1994 study of North Carolina schools where 38% of the high schools are on some form of a block schedule reports that student scores on statewide tests have neither increased nor decreased in schools using a block schedule (Sommerfield, 1996). These results are supported by Spencer & Lowe (1994) in their study of four classes of ninth grade students in a block schedule of classes lasting for 120 minutes for one semester. Spencer and Lowe (1994) report insignificant differences in achievement between students on a block schedule and those on a traditional schedule. Meadows (1995) finds no evidence that scores on English or math district summative tests or AP scores are affected by the 4 X 4 block schedule.

Thus, while Fallon (1995) concludes that a review of literature provides for at least equivalent achievement if not increased achievement for students on a block schedule, the question of the effect of block schedules on achievement remains.

Disadvantages of Block Schedules

In spite of the many advantages of block schedules, a number of disadvantages are identified by educators and parents. Most studies to date are attitudinal surveys and lack an empirical base for determining what occurs relative to student achievement (Brophy, 1978). The disadvantages of block schedules identified by educators and parents focus on two primary areas: (1) its effect on performing arts classes, and (2) the effect on knowledge retention in skill/concept-based classes such as mathematics and foreign language.

Educators: Effect on Performing Arts

Abeel and Caldwell (1996) criticize the 4 X 4 block schedule of classes meeting for 90 minutes for one semester because of its negative impact on music and performing arts programs. Abeel (1996) contends that "this innovative teaching method is killing the music program in high schools where the schedule doesn't allow for daily meetings of band, orchestra, and chorus. Enrollments have dropped by as much as half of what they were 'pre-block'" (p. 46).

Abeel and Caldwell (1996), citing a study by Hall (1992), points out that "disciplines that depend on continuous study suffer. Classes in performing arts suffer because students who drop out do not return and those who do return are deficient in skills. Also, only about three-fourths of the class time is used efficiently" (p. 46). According to Abeel and Caldwell (1996), more class time in a block scheduled class period is used for completing homework or in transition from one activity to the next than what was used in the traditional class period of 45 to 50 minutes.

Studies on Knowledge Retention

There is little statistical research in the public school setting on knowledge retention. Naveh-Benjamin (1990) cites the need for "educationally relevant memory research that considers real classroom content and learning and retention." Such research, he contends, will benefit educational practice and memory theory. However, there are research studies on knowledge retention that report factors influencing it that are relative to this study.

Schoenfeld (1987) explains the relationship between memory and mathematics education. Schoenfeld compartmentalizes memory into three areas; the sensory buffer, the working memory (short-term memory), and the long-term memory (LTM). The sensory buffer can receive information simultaneously, but can hold it only briefly. It then transfers the information to the working memory. The working memory is where all the "cognitive" action takes place and where information is processed for the LTM. The working memory contains all the information that is being used all the time. The LTM is the storehouse for mathematical knowledge, and information from it can be accessed and used in the working memory.

Citing the research of Calfee (1981), Carroll (1994) states that if students are to retain knowledge in the LTM, the information must be acquired in a well-organized manner. According to cognitive psychologists,

> if a person is presented with well-organized material in conditions that allow for a high level of individual attention, he or she will learn well, and what is learned well goes into the LTM in an organized manner. As a result it can be recalled more easily. Teaching under a traditional schedule does not allow for the conditions for learning recommended by cognitive psychologists. (Carroll, 1994, p. 83)

On the other hand, critics of block schedules may argue that the intensity of mathematics instruction, 90 minutes per day for 90 days, may interfere with the transfer of information from the sensory buffer to the working memory and LTM in a way that allows for retrieval of information from the LTM as needed.

Researchers studying knowledge retention have identified two primary predictors of retention: (1) how well the original learning occurred and (2) the type of learning, that is, recall compared to comprehension or application of knowledge. The first predictor, how well the original learning occurred, is supported by several research studies. The importance of retention is that the improvement in skills and knowledge is dependent upon the learner's retention of the previously learned skills and knowledge (Hunter, 1982; Musser, 1983; Spitzer, 1939). Musser (1983) reports that a "task is easy or hard and material is comprehensible or not to the extent that it maps out pre-existing knowledge" (p. 96). Bahrick's research (1984) also shows higher levels of knowledge retention for students who achieved higher grades and who took more classes. Thus, Bahrick also concludes that knowledge retention can be predicted by the initial depth of learning. Studies by Shuell and Giglio (1973) also suggest that "forgetting rates" will be comparable if the former achievement rates are equated. However, Bahrick (1979) states that much of what is learned during a first exposure is forgotten during the interval between exposures and must be relearned later. Bahrick (1979) also notes that most of the experimental research concerning memory has never dealt with problems on the acquisition and retention of knowledge in the normal school setting.

The second predictor of knowledge retention is the type of learning, that is, recall compared to comprehension or application of knowledge. In a study of the ability of high school graduates to recognize names and faces of classmates, Bahrick, Bahrick, and Wittlinger (1975) report that retention as assessed by free recall showed a steady decline with an increasing retention interval. In another study of high school Spanish students, Bahrick (1984) reports that recognition tests showed a higher level of retention than recall tests. Conway, Cohen, and Stanhope (1991), in a study of college, cognitive psychology students, report similar results. In this study, the retention interval ranged from three months to 125 months. The results showed a rapid decline in memory over the first few years of the retention interval, which then leveled out. The researchers also note that the initial decline in the retention of concepts was less rapid than for the recall of knowledge for specific facts. Semb, Ellis, & Araujo (1993) conducted a study with college students to determine the amount of information students remembered at four and 11 months after completing a course. The results showed that after four months, students retained 85% of what they had learned, and after 11 months, 80% of what was learned. Semb, Ellis, and Araujo (1993) also note that retention over time was greatly affected by the degree of original learning and that the retention of recall facts is significantly lower than for recognition, comprehension, and application of knowledge. Likewise, Conway et al. (1991) report that the recall of facts declines more rapidly than the retention of concepts. Silver (1981), in a study of seventh grade mathematics students, states that high ability students are more likely to recall information about the structure of mathematics problems (concept), whereas lower ability students tend to recall information about the context of the problem (recall).

In a study of upper elementary school students, the extent of forgetting mathematics information over the period of one summer was investigated. Using different forms of the California Achievement Test as a pre-and post-test, it was found that the retention of mathematics skills taught in the spring semester did not significantly change over the summer months (Weiss, 1988).

In addition to the two predictors of knowledge retention described above, how well the original learning occurred and the type of learning, Semb, Ellis, and Araujo (1992) discuss the effect of other variables on LTM of knowledge learned in the classroom; the task to be learned, characteristics of the retention interval, the method of instruction, the manner in which memory is tested, and individual differences. Of these factors, the degree of original learning, characteristics of the retention interval as defined by time, and the manner in which memory is tested are of particular interest for this study. Bahrick and Hall (1991) suggest that retention losses are relatively unaffected by individual difference variables pertaining to aptitude and achievement, and instead are more influenced by manipulative variables pertaining to curriculum and schedule of instruction. Bahrick and Hall recommend a change from a quarter schedule to a semester schedule while keeping the total number of hours constant.

A study of the effect of a block schedule on knowledge retention was conducted after one year of implementation of the Copernican Plan in the Masconomet Regional High School. In the second year of the implementation of the Copernican Plan, in September, December, and March, comparisons were made of the retention of material studied during the first year. These comparisons, referred to as "gap tests" were administered from three to fifteen months after the courses ended. No significant difference was found that favored students in the Copernican Plan over students in the traditional schedule. Both groups had comparable levels of retention (Carroll, 1994).

Studies by Walberg (1988) confirm the importance of time for learning. He concludes that the amount of time students are engaged in learning has a powerful and consistent effect on the amount of learning that takes place. With the implementation of the block schedule, the time for learning a particular subject increased from 45 minutes to 90 minutes daily. However, the total amount of time remained constant since what was traditionally taught for 180 days of 45 minute class periods was reduced to 90 days of 90-minute class periods.

Effect of Block Schedules on Knowledge Retention

The adoption of a 4 X 4 block schedule raises reasonable questions about students' retention of what they have learned since a year or more may elapse between courses in the same subject (Canady & Rettig, 1996; Carroll, 1990). Some educators and parents believe that students will forget too much if they are out of class for more than a three month summer vacation (Carroll, 1994). The literature reports contradictory results for the effect of the block schedule on retention.

In a study by Christy (1993) that compared the performance of college students in biochemistry, from block and traditional schedules, no significant difference in knowledge retention is reported. Similar results are noted in the research by Carroll (1994) of students at Masconomet Regional High School in Massachusetts. After one year in the Copernican Plan, gap tests given at three, eleven and fifteen months show no significant difference in retention between students on a traditional schedule and students on a block schedule.

In a study at the end of the school year by Bateson (1990) of students in grade 10 in British Columbia schools, findings show that students in full year courses consistently outperformed both first and second semester students in the cognitive domains tested. Another important finding of this study is that second-semester students outperformed the first-semester students. Bateson notes that this "casts doubt on the teacher perception that knowledge retention is of little concern under a semester system" (p. 233). Kramer (1996), citing studies by Stennett and Rachar (1973) and Smythe, Stennett, and Rachar (1974), reports "that students with an extra semester off from a course had more difficulty recalling recently learned concepts, but they recovered quickly during the subsequent mathematics course. Over the long term, no negative effects were caused by the time off'" (p. 762), and, according to Carroll (1990), "evidence indicates that retention under this type of schedule will be as good or better than under a traditional schedule" (p. 362). In a survey study by Averett (1994) of 21 North Carolina schools on a block schedule, teachers report that the block schedule had a "moderate positive effect" or a "strong positive effect" on retention of subject matter.

Effect of a Block Schedule on Mathematics Achievement

Spencer (1994) reports that when students in Algebra I were given a standardized test at the end of the year, there was no significant difference between students on a 4 X 4 block schedule and students on a traditional schedule. Likewise, Schroth and Dixon (1995) report no significant difference in achievement, as measured by the Texas Assessment of Academic Skills, in lower achieving seventh graders between those on an A/B day block schedule of 90-minute classes and those on a traditional schedule. After nearly 20 years of block schedules in Canadian schools, a trend is emerging showing lower mathematics achievement in students who follow block schedules (NCTM, 1996; Kramer, 1997). In a study by Raphael, Wahlstrom, and McLean (1986) of 250 mathematics classrooms in 80 Ontario schools, performances of grade 12 and 13 students in classes lasting only one semester were significantly lower than those in year-long classes. In a comparison of 1995 end-of-course test scores for blocked and non-blocked schools in North Carolina, the North Carolina Department of Public Instruction reports a decline in mean t scores in geometry in schools with a block schedule from 52.04 in 1993 to 49.49 in 1995, a difference of 3.55. However, the mean t scores of schools with a block schedule for all subjects were consistently higher than in schools with a traditional schedule and statistically significant at the .01 level. Guskey and Kifer (1995) report that after one year on a 4 X 4 block schedule, student performance in accelerated pre-algebra on a district summative test dropped from a three year average of 86% on the traditional schedule to 83% on the block schedule. Guskey and Kifer (1995) also report that the three-year average of students in precalculus dropped from 73% on a district summative test to 70%. A four-year summary report of a large suburban high school using the 4 X 4 block schedule showed the percentage of students attaining a mastery score of 80% on district summative tests in mathematics dropped from 48% in the last year of a traditional schedule to 38% after

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four years on the 4 X 4 block schedule (Governor Thomas Johnson High School, Four-Year Summary Report, 1996). Schoenstein (1995) reports that SAT scores in mathematics dropped from 493 to 482 over a five year period and ACT scores dropped from 20.1 to 20.0. Since the demographics of the school have changed dramatically since the implementation of the 4 X 4 block schedule, Schoenstein is uncertain if the drop in scores is the result of the block schedule or the change in demographics.

Relationship Between the Review of Literature and Present Study

The literature on block schedules and more specifically the effect of block schedules on knowledge retention indicates contradictory results. Much of the literature is from anecdotal, attitudinal, and observational studies so there is little student performance information to show the effect of a block schedule on knowledge retention in mathematics . Also, the literature reflects a major concern of some parents and educators about the effect of block schedules on knowledge retention. This research studied the effect of block schedules on the knowledge retention of mathematics skills/concepts for students in precalculus after a retention interval ranging from zero to 12 months.

Secondly, the literature shows that the effect on retention will be no greater than what traditionally occurred over a three-month summer break, and after a review of skills/concepts by the teacher, student performance will be equivalent to what it was before the retention interval. This study examined this claim by administering a post-review test in Algebra 2 after the completion of the review of skills/concepts by the teacher.

The literature on block schedules lists many advantages of the block schedule, one of which is the change in the instructional practices used by teachers. As part of the study, classroom observations of mathematics teachers were conducted to examine the practices used by the teacher in a block schedule, especially during the time of review of previously learned concepts.

Summary of Literature Review

This review of literature covered an examination of the traditional organization of the use of time in public schools and subsequent calls to reorganize the utilization of time. The advantages and disadvantages of block schedules, as expressed by educators and parents, were discussed. The effect of block schedules on achievement, and specifically on knowledge retention, were examined. Prior research studies on knowledge retention were reviewed.

This researcher concludes that gaps exist in the literature relating to the effect of block schedules on knowledge retention in mathematics. Also, there is no literature reporting strategies used by teachers to review previously learned mathematics skills/ concepts in order to accommodate the varying retention intervals with which a group of students enter a new mathematics course.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Introduction

The study examined a concern of educators and parents regarding knowledge retention and subsequent reacquisition of mathematics skills/concepts after varying retention intervals since the completion of the last mathematics course. The variation in retention intervals ranged from zero to 12 months because mathematics courses on a block schedule were taken for one semester. Students could maintain the continuity of mathematics courses by completing one mathematics course in each of the two semesters of a school year. On the block schedule, students more typically skipped one or more semesters of mathematics study before taking the next mathematics course in the sequence. The study also examined the instructional practices used by mathematics teachers in a block scheduled class period of 90 minutes.

This chapter includes a complete description of the research questions, the dependent and independent variables for the research questions, the sample for the study, and the testing instruments. Also included is a description of how the data were analyzed.

Research Design

This study was a quasi-experimental design, one in which subjects were not randomly assigned to groups (Pedhazur, 1982; Shavelson, 1988). The validity of the study considers both internal and external validity factors. Relevant to internal validity, two types of extraneous variables are considered. The first type is maturation of the respondents. According to Campbell and Stanley (1963), maturation processes are those within the participants operating as a function of time, including growing older. In this study, approximately one-third of the participants will be one year older and another one-third eight months older than they were at the completion of the Algebra 2 study. A second type is testing which considers the effects of taking a test upon the scores of a second testing. According to Campbell and Stanley (1963), students taking the achievement test for a second time, or taking an alternate form of the test, usually do better than those taking the test for the first time. In this study, students will have taken the same multiple choice component of the end-of-course test three times and the performance-based assessment twice. The internal validity of this study could have been strengthened by the use of a control group since a control group reduces the practice effects of testing. A factor which influences the external validity, or generalizability, is the reactive or interaction effect on testing when a pre-test is used. According to Campbell and Stanley (1963),

> a pre-test might increase or decrease the participant's sensitivity or responsiveness to the experimental variable and thus make the results obtained for a pretested population unrepresentative of the effects of the experimental variable for the unpretested universe from which the experimental participants were selected. (p. 17)

The interaction effect will preclude generalizations about the study to other students and schools beyond the experimental setting of this study.

The purpose of the study was to examine the effect of the block schedule on knowledge retention of mathematics skills/concepts, specifically Algebra 2, for students having a retention interval ranging from zero to 12 months. (Retention interval is defined in this study as the time period between the initial exposure to facts and concepts and the second exposure.) The study also examined the reacquisition of mathematics skills/concepts by the students who showed a knowledge retention loss after a period of review by the classroom teacher. Thirdly, the study examined the effect of a lengthened retention interval on mathematics achievement in the subsequent course, precalculus. Finally, because students enter a mathematics course with varying retention intervals, the study examined qualitatively the instructional strategies used by teachers to eliminate the effect of the retention interval for all students beginning a new course of mathematics study.

Research Questions

This study examined the effects of a block schedule in two suburban high schools on knowledge retention of mathematics skills/concepts, specifically Algebra 2. Secondly, the strategies used by teachers during review for students to reacquire mathematics concepts/skills were observed. More specifically, answers to the following questions were sought:

1. Is there a significant difference in scores on a pre-review test given at the beginning of a precalculus course among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
2. Is there a significant difference in scores on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
3. Is there a significant difference in scores on an end-of-course test in precalculus among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months) before entering the precalculus course?

4. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
5. Is there a significant difference in the scores of precalculus-merit students on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
6. Is there a significant difference in the scores on an end-of-course test in precalculus among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
7. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
8. Is there a significant difference in the scores on a post-review test given at the end of the teacher review of approximately four weeks among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
9. Is there a significant difference in the scores on an end of-course test in precalculus among three groups of precalculus-honors students

identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

10. What instructional strategies are used by teachers to review Algebra 2 skills/concepts so that students can reacquire previously learned skills/concepts that may have been lost during the retention interval?

Dependent Variable for Research Questions

The dependent variable for the research questions was knowledge retention of Algebra 2 skills/concepts as measured by an end-of-course test consisting of two parts, a 37-item multiple choice component and one performance-based assessment. The multiple choice test was given three times: at the end of the Algebra 2 course of study (baseline data), on the first day of the precalculus course (pre-review test), and after the review of Algebra 2 skills/concepts (post-review test), approximately four weeks after the beginning of the precalculus course. The performance-based assessment was given twice, once at the beginning of the precalculus course and again at the end of the teacher review, approximately four weeks later. An end-of-course test consisting of a 37-item multiple choice component and a performance-based assessment was also given at the end of the precalculus course.

Independent Variables for Research Questions

The independent variables for the research questions were time, as measured by the retention interval between the Algebra 2 and precalculus course, ability level (honors and merit), gender, race, Functional Mathematics Test score, final grade for Algebra I and Algebra 2, and the student characteristics of socioeconomic status (SES) as indicated by free/reduced lunch, race, gender, and school (A or B) (Figure 1).

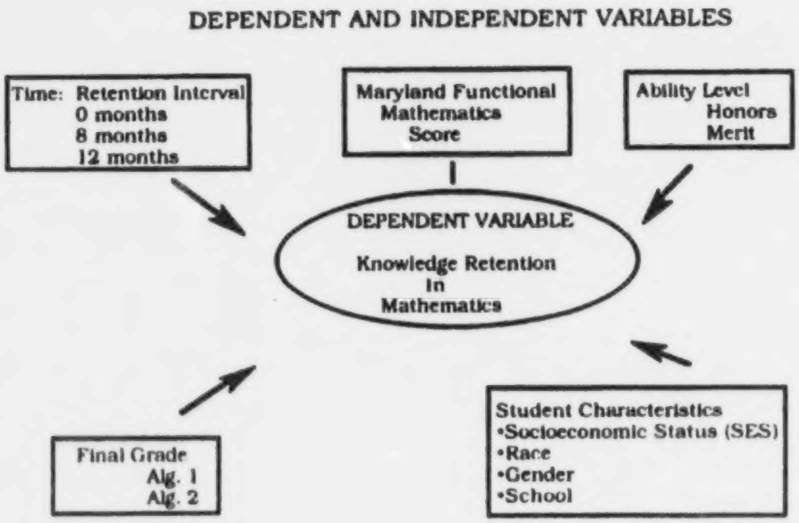
DEPENDENT AND INDEPENDENT VARIABLES
Time: Retention Interval
0 months
8 months
12 months
Maryland Functional Mathematics Score
Ability Level
Honors
Merit
DEPENDENT VARIABLE
Knowledge Retention In Mathematics
Final Grade
Alg. 1
Alg. 2
Student Characteristics
•Socioeconomic Status (SES)
•Race
•Gender
•School

Figure 1. Dependent and independent variables

Time, as measured by the retention interval, was determined by the number of months since the student completed the Algebra 2 course. For this study, the time measurements were zero months, eight months, and 12 months.

Ability level was determined from student records. For this study, students already identified and enrolled in precalculus as honors or merit students were used. Students in the honors level typically were working one grade level ahead in their mathematics study. Students in the merit level were working at a performance level equal to their grade level in mathematics. Although there was a directed level for students working one grade level behind in their mathematics study, there was no precalculus course offered at this level. Any student taking precalculus must have enrolled in either the precalculus honors or precalculus merit course. Gender and race of the student participants was determined from course enrollment lists and cumulative file information.

The socioeconomic status of student participants was determined from a comparison of course enrollment lists to the free/reduced lunch records of the school.

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These records are updated monthly as students qualify for or are removed from this program.

The Functional Mathematics Test (FMT) scores for student participants were secured from the testing data file which is part of the students' cumulative file. The FMT is viewed as a test of basic skills and as a possible predictor of mathematics achievement.

The final letter grades (A, B, C, D) for Algebra 1 and Algebra 2 were gathered from report cards and students' permanent record cards. In the school system of this study, a grade of A or B is considered mastery of the mathematics course.

The school of the student participants was identified as either School A or School B. Although the two schools of this study were chosen in part because of their similarities in demographics and achievement, school will be considered as an independent variable.

The student test score for Algebra 2, as identified on individual answer sheets, on the end-of-course test was used as the baseline score in all parts of the study.

Research Methodology

Sample

The sample for this study (n = 172) included seven class sections of precalculus students, four precalculus-honors sections and three precalculus-merit sections, in the spring semester, from two suburban high schools located in a mid-Atlantic public school district of 31,655 students. The total population of precalculus students in the 1996-97 school year was not used since approximately 50% completed precalculus in the fall semester of the 1996-97 school year. Algebra 2 and precalculus were chosen for the study because of their linear sequence, one course following the other without the interruption by another course, as occurs between Algebra 1 and Algebra 2 with the study of geometry.

Schools in the Study

The two high schools used in the study were located in a suburban city and were two of eight high schools in the district. The two high schools used in the study were selected for two reasons: (1) both schools had been on a block schedule for four or more years so the teachers and students were accustomed to instruction and testing in a 90-minute block, and (2) the two high schools were very similar in demographics and were representative of many high schools in the state in which they were located.

The schools' and districts' wealth per student was reported to be $195,084 with a per pupil expenditure of $5,514; the state's wealth per student was $234,091 with a per pupil expenditure of $6,106. School A had more students on free/reduced lunch (15.2%) than the district (14.5%), but less than the state (30.4%). School B had fewer students on free/reduced lunch (11.2%) than the district or the state (______ County Public Schools, 1996).

School A had a total student population of 1,881 students and a non-white population of 24%, of which 17% were African-American. School B had a total student population of 1,495 students and a non-white population of 17%, of which 12% were African-American (______ County Public Schools, 1996).

The two high schools had similar numbers of students making a post-secondary education decision. School A had 38.9% of its students going to a four-year college and 19.8% going to a two-year college. School B had 39.8% of its students going to a four-year college and 25.4% going to a two-year college (______ County Public Schools, 1996).

Based on test scores from a state mandated mathematics test of functional mathematics skills administered to all students beginning in grade 7, the Functional

Mathematics Test (FMT) mathematics achievement of the students in the two high schools in this study was representative of the students in the district, but not necessarily of students in the state where the two high schools are located. Passage of this test with a minimum of 80% was a graduation requirement. School A had a passage rate for ninth grade students of 94.4% and a passage rate for eleventh grade students of 99.2%. School B had a passage rate for ninth grade students of 94.5% and for eleventh grade students of 99.3%. The passage rate for ninth grade students for the district was 94.9%, and the passage rate for eleventh grade students was 99.3%. The passage rate for ninth grade students at the state level was 81.8% and 96.4% for eleventh grade students (______ County Public Schools, 1996).

Based on the scores on end-of-course tests that are given in all mathematics courses as part of the district's Criterion-Referenced Evaluation System (CRES), both schools scored lower than the district score. School A had 36.0% of all students in mathematics score at or above mastery (80%), compared to 44% for the district. School B had 38% of all students in mathematics scoring at or above mastery, compared to 44% for the district. On the end-of-course test for Algebra 2, School A had 46.5% of the students scoring at or above mastery, and School B had 46.4% of the students scoring at or above mastery (Table 1). The percentage of students scoring above 1,000 on the Scholastic Aptitude Test (SAT) was lower at both schools than the state percentage. The percentage at School A (37.7%) was lower than that of the district (39.4%). The percentage at School B (41.4%) was higher than the percentage for the district.

Table 1

Characteristics of School Populations

	School A (%)	School B (%)	District (%)	State (%)
Non-white	24.0	17.0	12.0	43.3
African American	17.0	12.0	8.0	
Free/Reduced Lunch	15.2	11.2	14.5	30.4
Post-Secondary Decisions				
4 year college	38.9	39.8	33.0	42.7
2 year college	19.8	25.4	27.5	18.2
FMT Passage Rate				
9	94.4	94.5	94.9	81.8
11	99.2	99.3	99.3	96.4
District Summative Test (CRES)				
All math	36.0	38.0	44.0	
Algebra 2	46.5	46.4		
SAT (above 1000)	37.7	41.4	39.4	49.0

____________ County Public Schools, 1996

Thus the higher mathematics achievement for the state mathematics test and the lower achievement on the school district summative tests may limit generalization of the study's results to other populations.

Teacher Participants

The sample (n = 4) was comprised of all teachers of precalculus for the second semester in the two schools involved in the study. Two of the four teachers, one male and one female at each of the two high schools, taught the precalculus-honors course. Three of the four teachers, one male and two females, taught the precalculus-merit course. The sample of teachers, all Caucasian, was comprised of four certificated mathematics teachers, with three of the teachers, one female and two males, having twenty or more years of experience. One teacher, a female, had five years of experience. All teachers in the sample had test administration experience of five years or more with the school district end-of-course test used in the study.

In a meeting held with the mathematics curriculum specialist for secondary schools of the school district of this study, preliminary plans for the research study were discussed. This meeting was held with the mathematics department chairpersons of the two high schools and with the four teachers involved in the study early in the semester prior to the semester in which the study was conducted. The purpose and methodology of the study were discussed. All four teachers agreed to participate in the study by administering the end-of-course test in Algebra 2 as the pre-review test on the first day and second day of the second semester, precalculus class, and again after a four-week review (post-review test) of Algebra 2 skills/concepts was completed. During the first class session of the precalculus course, each teacher informed the students about the general purpose of the study and why they would be repeating the end-of-course test taken at the end of the Algebra 2 course. Teachers assisted in the supervision and proctoring of each test administration. Finally, at the end of the semester of precalculus study, teacher participants provided the researcher with the end-of-course test data for the precalculus students.

Student Participants

The student sample (n = 172) for this study included all students in seven class sections of precalculus, four precalculus-honors sections and three precalculus-merit sections. The honors instructional level typically connotes performance beyond one's grade level in a subject of one or more years. The merit instructional level indicates performance at grade level in a subject. A total of 172 students were involved in the study. By grade level, two ninth grade students, 38 tenth grade students, 98 eleventh

67

grade students, and 34 twelfth grade students participated in the study. By academic level, 109 precalculus-honors students and 64 precalculus-merit students participated in the study. The sample was predominantly white with 18.02% nonwhite students.

Procedure

Permission to conduct this study was granted by the Manager of Measurement and Statistical Analysis of the school district in which the study was conducted (Appendix A).

A meeting with the mathematics curriculum specialist for secondary schools, schools' principals, mathematics department chairpersons, and teachers of precalculus was held in the first months of the semester prior to the study. In this meeting, the purpose of the study, the significance of the study, and the data gathering procedures for the study were discussed. Each teacher in the study was asked to accept responsibility for informing students about the general purpose of the study according to the guidelines provided by the researcher (Appendix B).

All students enrolled in precalculus-honors and precalculus-merit for the second semester of the school year participated in the study unless their parents requested they be omitted. Parents were notified of the study through a letter (Appendix C) sent home with students approximately two weeks before the study began. The parents were asked to notify the school if they wished to have their child withdrawn from participation in the study.

At the end of the Algebra 2 course, lasting one semester, all students in the study were given an end-of-course test. This test consisted of 37 multiple choice items and two performance-based assessments. Student scores from the Algebra 2 end-of-course administration of the multiple choice component of the end-of-course test were used as baseline data. Scores were not available for the performance-based assessments to use as a baseline score for this component of the end-of-course test.

To study the knowledge retention of Algebra 2 skills/concepts, students taking precalculus-honors and precalculus-merit were given the same end-of-course test as was given at the end of the Algebra 2 course (pre-review test). Both the multiple choice component and one performance-based assessment were given. Since there were no baseline scores available for the performance based assessment given at the end of Algebra 2, the student scores on this component (pre-review test) were compared to the student scores on the post-review test. The test was given in the normal classroom setting on the first and second day of the semester of precalculus.

To study the reacquisition of Algebra 2 concepts, both components of the end-of-course test were repeated after the teacher concluded the review chapters for Algebra 2 (post-review test). A different version of the performance-based assessment was used. The test was given in the normal classroom setting approximately four weeks after the semester began.

To study the effect of a lengthened retention interval on mathematics achievement in the subsequent mathematics course, student scores on the end-of-course test in precalculus were compared by retention interval. The precalculus end-of-course test was given at the end of the semester of precalculus study in a normal classroom setting.

Classroom observations were to be conducted to study the strategies used by mathematics teachers in reviewing the skills/concepts of a prerequisite mathematics course. The observations were to be done each day until the review was completed and the post-review test was given. A checklist of instructional strategies was used for recording the type and duration of each strategy (Appendix D). However, because of a conflict in teacher schedules, observations were done of the four teachers in the study on alternate days for approximately four weeks. The teachers at School A were observed on one day (Day 1) and the teachers at School B were observed the next (Day 2) until all teachers completed the review of Algebra 2 concepts (Table 2).

Table 2

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Observation Schedule

		Day 1		Day 2
School A	Teacher 1:	Precalculus, merit 8:00-9:32 a.m.		
	Teacher 2:	Precalculus, honors 11:13-1:15 p.m.		
School B			Teacher 3:	Precalculus, merit 11:13-1:15 p.m.
			Teacher 4:	Precalculus, honors 1:20-2:50 p.m.

Testing Instruments

The testing instruments in this study included one version of a 37-item multiple choice component and two versions of the same performance-based assessment for Algebra 2 and a multiple choice component and two performance-based assessments for precalculus. All testing instruments were the components of an end-of-course test routinely given at the end of all the respective mathematics courses. This test was part of a larger Criterion-Referenced Evaluation System used in the school district to assess student achievement at the completion of a course of study in all subject areas. The test used in this study was developed by mathematics teachers in the district under the supervision of the mathematics curriculum specialist for secondary schools.

End-of-Course Test

The end-of-course test for Algebra 2 was administered at the end of the semester in which students completed Algebra 2, honors or merit. For this study, the test was given to students again during the first two class sessions of precalculus-

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honors and precalculus-merit (pre-review test). The test was repeated after the precalculus teacher completed the review of algebra skills/concepts, approximately four weeks into the course of precalculus study (post-review test). The end-of-course test for precalculus was given at the end of the semester of the precalculus course.

The end-of-course test for Algebra 2 and precalculus administered to students in this study was a district-mandated test that assesses student mastery of Algebra 2 and precalculus skills/concepts. The version of the end-of-course test used in this study consisted of 37 multiple choice items and one performance-based assessment for Algebra 2 and 37 multiple choice items and two performance-based assessments for precalculus. All questions of the multiple choice component tested comprehension and/or application of Algebra 2 or precalculus skills/concepts. The performance based assessment tested the application of Algebra 2 and precalculus concepts in a new situation. Mastery of Algebra 2 and precalculus skills/concepts, as measured by combined scores on the two components of the test and standards established by the school district, was 80%. A score ranging from 79% to 60%, though not indicating failing, did indicate performance below mastery.

Test Reliability and Validity

While no reliability test has been done on the end-of-course test, use of the test in the school district for five or more years has shown it to be acceptable by school district officials for assessing student achievement and effectiveness of program. Scores from the tests are used for reporting district-wide student achievement. Reliability of teacher scoring of the performance-based assessments was done each summer using a small sample of student test results from each school. The validity of the school district summative test is measured by its alignment with the essential curriculum objectives. The school district summative test is written by district teachers of the course and reflect the concepts and skills expected by Algebra 2 teachers.

Data Analysis

Description of the demographic data analysis and quantitative analysis of the research questions is provided in this section.

Demographic Data Analysis

In the demographic data analysis, descriptive statistics (percentages and means) were calculated and reported for the (a) characteristics of the participating students and teachers; and (b) student performance on the baseline test scores administered at the completion of Algebra 2, the pre-test at the beginning of the precalculus study, the post-test at the completion of the review of Algebra 2 concepts, and the end-of-course test given at the end of the precalculus course.

Quantitative Analysis of the Research Questions

To analyze the student test scores (dependent variable) and to compare the differences among the groups of students by retention interval (zero months, eight months, and 12 months), independent t tests and the analysis of variance (ANOVA) were used. To compare the student scores on the Algebra 2 end-of-course test and the precalculus end-of-course test, dependent tests were used. Using end of semester grades in Algebra 1 and 2, Functional Math Test scores, and the baseline score from the Algebra 2 end-of-course test as covariates, the analysis of variance (ANOVA) and the Scheffé test were used to compare the test score (dependent variable) differences among the three groups of students by retention interval.

Qualitative Analysis

The second major research question, regarding the strategies teachers use to review for a reacquisition of previously learned mathematics concepts, was analyzed qualitatively. Teaching strategies (practices) during the time of review were timed and categorized. The strategies were examined for discernible strategies named in the literature. A comparison of strategies used by teachers during the review to those strategies favored in the literature for teaching in a block schedule was conducted.

Limitations

There are a number of limitations to this study. One limitation is the use of the same testing instrument three times. According to Spitzer (1939), in studies where the same tests are repeated, the effect on recall of the test items should be recognized. By the third administration of the same test, after the teacher reviews Algebra 2 skills/ concepts, test familiarity may be a limitation.

Another limitation is that the results of this study may not be generalizable to students in other schools or school districts. The results may not be generalizable for the following reasons:

1. The study included only two high schools, both of which were large, suburban high schools;
2. The school district being studied was predominantly suburban; and
3. The participants in the study are all students in upper level mathematics courses.

To assess if students are able to reacquire mathematics knowledge lost during the retention interval between mathematics courses, the end-of-course test was repeated after the review of Algebra 2 concepts. A limitation is that all teachers involved in the study may not review Algebra 2 concepts/ skills with students, using the same instructional strategies. The variations may have an impact on student test scores on the third administration.

Advocates of block schedules argue that the effect on knowledge retention of skills/concepts is little different from what occurred in the traditional schedule with a three-month summer break. A limitation of this study is that none of the groups studied had a retention interval of only three months. Instead, student participants in the study completed Algebra 2 in January, 1996 (retention interval of 12 months); June, 1996 (retention interval of 8 months); or January, 1997 (retention interval of zero months).

Finally, researcher bias and position may affect this study. The researcher conducting this study was a science teacher and school administrator in this school district for 10 years, and a science curriculum specialist in the district for three years. The researcher was an assistant principal in one school in the study four years prior to the implementation of a block schedule at that school. As a science curriculum specialist and at varying times as block schedules were being implemented in the school district, the researcher was involved in meetings with school and district staff members, parents, and students. At these meetings, the advantages and disadvantages of block schedules were discussed. Also, as a middle school principal, the researcher often received questions about the effect of the block schedule on mathematics from parents of eighth grade students moving to a block schedule in high school.

Despite these limitations, the study offers data and results that will be of use to educators and parents who have questions about the effect of block schedules on the retention of knowledge.

Summary of Procedural Protocol

The following protocol was used in this study:

1. The researcher obtained permission to conduct this study from the Manager of Measurement and Statistical Analysis of the school district in which the study was conducted.
2. The researcher selected the sample for the study.
3. The researcher met with the mathematics curriculum specialist for secondary schools and each of the school principals in the two schools

where the study was conducted to explain the nature and purpose of the research study.

4. The researcher met with each of the mathematics department chairpersons in the two schools where the study was conducted to explain the nature and purpose of the research study and to enlist their support within the mathematics department.
5. The researcher met with the teacher participants in the two schools where the study was conducted to explain purpose of the research study and guidelines for the study.
6. The researcher studied student information files to obtain demographic, achievement, and testing data.
7. The researcher contacted the parents of the student participants by letter to explain the nature and purpose of the research and to receive their permission to involve their child in the study.
8. The researcher organized all testing materials and distributed these along with printed guidelines to the teacher participants.
9. The researcher observed the teacher participants during a four-week period of instruction in which Algebra 2 concepts/skills were reviewed.
10. The researcher performed and analyzed relevant statistical analyses on the testing data.
11. The researcher compared the instructional pedagogy used by the teacher participants during the classroom observations to the literature findings on instructional pedagogy for a block schedule.

CHAPTER IV

RESULTS

Introduction

Since the early 1990s, a restructuring of the traditional high school schedule has occurred at a rapid pace. One of the results of the restructuring was a 4 X 4 block schedule in which students took four classes per day of approximately 90 minutes each for one semester. With the opening of the 1996-97 school year, it was estimated that more than 40% of the high schools in the United States would be using some variation of a block schedule with the 4 X 4 block schedule being the most commonly used variation.

Statement of the Problem

Although it is popular among educators, students, and parents, critics of the 4 X 4 block schedule question its effect on knowledge retention when courses are taken for one semester and when students have a lapse (retention interval) of one or more semesters between courses of the same subjects. This question is especially prevalent for mathematics when students have a retention interval longer than the traditional three-month summer break between courses.

This study examined quantitatively the effects of varying retention intervals (RIs) within a 4 X 4 block schedule on knowledge retention of mathematics skills/concepts, specifically Algebra 2 skills/concepts, for students having a retention interval of zero, eight and 12 months and the subsequent performance in precalculus.

The study also examined qualitatively the strategies used by teachers to eliminate the effect of the retention interval for all students beginning a new course of mathematics study. This chapter reports the analysis of the data collected to answer the following research questions:

1. Is there a significant difference in scores on a pre-review test given at the beginning of a precalculus course among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
2. Is there a significant difference in scores on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
3. Is there a significant difference in scores on an end-of-course test in precalculus among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months) before entering the precalculus course?
4. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
5. Is there a significant difference in the scores of precalculus-merit students on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

6. Is there a significant difference in the scores on an end-of-course test in precalculus among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
7. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
8. Is there a significant difference in the scores on a post-review test given at the end of the teacher review of approximately four weeks among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
9. Is there a significant difference in the scores on an end of-course test in precalculus among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
10. What instructional strategies are used by teachers to review Algebra 2 skills/concepts so that students can reacquire previously learned skills/concepts that may have been lost during the retention interval?

The first section of the chapter examines the research questions of the study concerning the effect of varying retention intervals within a 4 X 4 block schedule on knowledge retention as measured by an end-of-course test in Algebra 2, a pre-review test, a post-review test, and an end-of-course test in precalculus. This section includes the data analysis necessary to determine

- the effect of varying retention intervals on knowledge retention as determined by pre-review test results;
- the reacquisition of mathematics skills/concepts as determined by an analysis of post-review test results;
- the effect of varying retention intervals within a block schedule on the knowledge retention of students of different ability levels, and
- the effect of varying retention intervals within a 4 X 4 block schedule on mathematics achievement in a subsequent mathematics course, in this case, precalculus.

The second section of the chapter reports the qualitative analysis of the instructional strategies used by mathematics teachers to review mathematics skills/ concepts so that students with varying retention intervals can reacquire those skills/ concepts.

Demographic Data

Before addressing the research questions of the study, it is important to review the demographic data of the schools and student participants in the study. This section includes an analysis of participation by student group membership. The analysis includes the presentation of data, a statement of the findings, and a discussion of the findings.

Schools in the Study

The two high schools used in the study were located in a suburban city and were two of eight high schools in the district. The two high schools were selected for two reasons: (1) both schools had been on a block schedule for four or more years so the teachers and students were accustomed to instruction and testing in a 90-minute block; and (2) the two high schools were very similar in demographics and were representative of high schools in the school district and state in which they were located.

School A had a total student population of 1,881 students and a non-white population of 24%, of which 17% were African-American. School B had a total student population of 1,495 students and a non-white population of 17%, of which 12% were African-American. The number of students on Free/Reduced lunch at School A was higher than that of the district, but lower than that of the state. The number of students at School B on Free/Reduced was lower than that of the district or state. The number of students making post-secondary decisions was higher at both schools than the district but lower than that of the state. At School A, the percentage of students making a four-year college decision was 38.9%, compared to 33.0% for the district. At School B, the percentage of students making a four-year college decision was 39.8%, compared to 33.0% for the district. The percentage of students passing the FMT (94.4% and 94.5%) was nearly the same as that of the school district (94.9%) but higher than that of the state (81.8%). The student performance on end-of-course tests was lower at both schools in the study (36.0% and 38%) than the percentage of the district (44.0%). Student performance on the end-of-course test in Algebra 2 was comparable at both schools (Table 3). At both schools, the percentage of students scoring above 1,000 on the Scholastic Aptitude Test (SAT) was lower than the percentage for the state. The percentage of students scoring above 1,000 at School A was lower (37.7%) than that of the district, whereas the percentage of students at School B was higher (41.4%) than the district.

Table 3

Characteristics of School Populations

	School A (%)	School B (%)	District (%)	State (%)
Non-white	24.0	17.0	82.0	43.3
African American	17.0	12.0	10.0	
Free/Reduced Lunch	15.2	11.2	14.5	30.4
Post-Secondary Decisions				
4 year college	38.9	39.8	33.0	42.7
2 year college	19.8	25.4	27.5	18.2
FMT Passage Rate				
9	94.4	94.5	94.9	81.8
11	99.2	99.3	99.3	96.4
End-of-course tests				
All math	36.0	38.0	44.0	NA
Algebra 2	46.5	46.4		
SAT (above 1,000)	37.7	41.4	39.4	49.0

____________ County Public Schools, 1996

Analysis of Participation by Student Membership Groups

All students (n = 172) enrolled in precalculus-honors and precalculus-merit elected to participate in the pre-review test and post-review test of the study. However, because some students enrolled in the precalculus course after the administration of the pre-review test, this score was not available for all students. Likewise, some students withdrew from precalculus before the administration of the post-review test. The student sample for the study included seven class sections of precalculus students, four precalculus-honors sections and three precalculus-merit sections. The demographic data showed that the majority of the participants were eleventh grade students and in precalculus-honors (Table 4).

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Table 4

Characteristics of Student Participants: Grade Level and Mathematics Level

	Number of Participants			
Grade Level	School A	School B	Total	%
9	00	02	02	01
10	19	19	38	22
11	51	47	98	57
12	29	05	34	20
	99	73	172	100
Mathematics Level				
Honors	51	58	109	63
Merit	48	15	63	37

Note: Total number of students = 172

By gender, there were more female participants than male participants. This was not representative of the ratio of male to female students in the school district in which 52% of the high school students are male and 48% are female, but it is representative of the student population enrolled in precalculus in the school district, of which 52.5% are female and 47.5% are male. Traditionally, more male than female students have enrolled in upper level mathematics courses. By race, a large majority of the participants were White and were on a paid lunch. The characteristics of student participants by gender, race, and socio-economic status are shown in Table 5.

Table 5

Characteristics of Student Participants

		Number of Participants	% in Study	% in District
Gender				
Male		71	41	52.0
Female		101	59	48.0
Race				
White		141	82	88.0
African-American		17	10	8.0
Other:	Asian	8	5	4.0 (all other)
	Hispanic	4	2	
	Indian	2	1	
Socio-economic Status (SES)				
Paid lunch		160	94	85.4
Free Lunch		8	5	11.0
Reduced Lunch		3	1	3.6

Note: Total number of students = 172

Students in the study completed the study of Algebra 2-honors and Algebra 2-merit at varying times, ranging from zero months to 12 months, prior to the study. Students with a retention interval (RI) of zero months completed the Algebra 2 course in the first semester of the school year in which the study was conducted (January, 1997). Students with an eight-month RI completed the Algebra 2 course at the end of the school year prior to the school year in which the study was conducted (June, 1996). Students with a 12-month RI completed the Algebra 2 course at the end of the first semester of the school year prior to the school year in which the study was conducted (January, 1996). School A and School B varied in having a large number of students at different RIs. Almost half of the students in the study at School B had an RI of 12 months with a large majority of these in precalculus-honors. Students at School A were more equally distributed among the RIs, but there were more students with an RI of eight months (Table 6).

Table 6

Student Characteristics by Retention Interval (RI)

Completed Algebra 2	RI (months)		Number of Participants	%
January, 1997	0			
		School A (H)	15	09
		School B (H)	17	10
		School A (M)	14	8
		School B (M)	7	4
			53	31
June,1996	8			
		School A (H)	23	13
		School B (H)	11	6
		School A (M)	19	11
		School B (M)	2	01
			55	31
January, 1996				
	12			
		School A (H)	13	8
		School B (H)	30	17
		School A (M)	15	9
		School B (M)	6	4
			64	38

Comparability of Students and Schools in the Study

Comparability of Students

Before discussing the analysis of the data from the end-of-course test in Algebra 2, pre-review test, and post-review test, it is important to establish the comparability among the students of the three groups by retention interval and the comparability of the two schools in the study. The statistical hypothesis stated there was no statistically significant difference in the means among the students in the three groups or between the two schools in the study. The means of dependent variables, including the final grade in Algebra 1 and Algebra 2, and the score on the Functional Mathematics Test (FMT), were calculated to find if there was a statistically significant difference among the means of the students in the three groups. A one-way analysis of variance showed no statistically significant difference among students in the final grades (based on a five-point scale) of Algebra 1 and Algebra 2 when students were sorted by retention interval (Table 7). The statistical hypothesis was accepted. There was no statistically significant difference among the students by retention interval based on these measures.

Table 7

Means of Dependent Variables by Retention Interval

RI (months)	Algebra 1		Algebra 2	
	Mean	SD	Mean	SD
0	4.31	.79	4.00	.93
8	4.35	.62	3.86	.85
12	4.18	.69	3.87	.96
F value	1.24		1.53	
F prob.	0.29		0.22	

Secondly, a one-way analysis of variance was done to establish similarity among the three groups of students by retention interval on a state mandated test of functional mathematics skills. The statistical hypothesis stated that there was no statistical difference in the means of the functional test among the three groups by retention interval. No statistically significant difference was found in the means on the functional mathematics test among the three groups by retention interval. The statistical hypothesis was accepted (Table 8).

Table 8

Means by Retention Interval on Functional Mathematics Test

RI (months)	Functional Mathematics Test	
	Mean	SD
0	373.09	23.16
8	375.44	20.74
12	375.46	18.72
F value	0.16	
F prob.	0.85	

Finally, a one-way analysis of variance was done to establish the comparability among the three groups of students by retention interval using the scores from the end-of-course test taken in Algebra 2. The statistical hypothesis stated there was no statistically significant difference in the means on the end-of-course test among the three groups by retention interval. The data analysis showed no statistically significant difference in the means among the three groups by retention interval on the end-of-course test in Algebra 2 (Table 9). The statistical hypothesis was accepted.

Table 9

End-of-course test in Algebra 2 by Retention Interval

RI (months)	Mean
0	30.40
8	30.61
12	29.93
F value	.10
F prob.	0.29

Comparability of Schools

An independent t-test conducted on the sample by school showed no statistically significant difference in the means on the Algebra 1 final grades or on the FMT scores for the two schools in the study. There was a statistically significant difference in the means on the Algebra 2 final grades (Table 10).

Table 10

T-test for Independent Sample of School

	Algebra 1		Algebra 2		FMT	
School	Mean	SD	Mean	SD	Mean	SD
A	4.23	.69	3.74	.95	376.4	20.47
B	4.33	.71	4.09	.85	372.6	20.89
t value	-.92		-2.5		1.18	
2-tail sig	0.36		0.01**		0.24	

$p = < .05^{*} \; < .01^{**}$

No statistically significant difference was found in the means on the end-of-course test in Algebra 2 and the pre-review test of the multiple choice component and on the pre-review test and post-review test of the performance-based assessment component. A significant difference was found in the means of the post-review test of the multiple choice component between the two schools. Students at School A had a higher mean on the multiple choice component of the post-review test than students at School B (Table 11).

Based on these analyses, the statistical hypothesis was accepted for all measures except the post-review test.

Table 12

Mean Scores by Retention Interval

	0 months	8 months	12 months	F-value
Baseline Algebra 2, end-of-course	30.40	30.61	29.93	.10
Pre-Review				
MC	30.00	21.52*	22.39**	39.19****
PBA	2.61	2.16	2.22	2.56
Post-Review				
MC	32.59	30.87	29.84**	4.83**
PBA	2.61	2.45	2.16	2.56
Precalculus, end-of-course				
MC	29.12	28.58	30.73	.97
PBA	3.09	2.82	3.07	1.21

p = < .05* < .01 ** < .001 *** < .0001 ****

Research Question #1

Is there a significant difference in scores on a pre-review test given at the beginning of a precalculus course among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the means on a pre-review test among three groups of students identified by the length of the retention interval.

A one-way analysis of variance and Scheffé test showed a significant difference in the means among the three groups of students by retention interval on the multiple choice component of the pre-review test. The data are presented in Table 12. The data in Table 12 indicate a significant difference in the means of the pre-review test among the three groups of students by retention interval. In this analysis a significant difference was found in the means of the pre-review test scores between students with a retention interval of zero months and eight months and between students with a retention interval of zero months and 12 months. No significant difference was found in the means of the pre-review test scores between students with a retention interval of eight months and 12 months. The statistical hypothesis was accepted on the multiple choice component of the pre-review test for students with a retention interval of eight months and 12 months. The statistical hypothesis was rejected for students with a retention interval of zero months and eight months and zero and 12 months.

On the pre-review test of the performance-based assessment, a one-way analysis of variance was used to determine if a statistically significant difference existed in the means of the scores on the performance-based assessment among the three groups by retention interval. The results showed no statistically significant difference in the means of the groups by retention interval (Table 12). The statistical hypothesis was accepted.

Research Question #2

Is there a significant difference in scores on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the means on a post-review test among three groups of students identified by the length of the retention interval.

A one-way analysis of variance and Scheffé test showed a significant difference in the means among the three groups of students by retention interval on the multiple choice component of the post-review test. The data are presented in Table 12. The data in Table 12 indicate a significant difference in the means of the post-review test among the three groups of students by retention interval. In this analysis a significant difference was found in the means of the post-review test scores between students with a retention interval of zero months and twelve months. No significant difference was found in the means of the post-review test scores of students with a retention interval of eight months and 12 months. The statistical hypothesis was accepted on the multiple choice component of the post-review test between students with a retention interval of eight months and 12 months. The statistical hypothesis was rejected between students with a retention interval of zero months and 12 months.

It is important to note that the mean of students with a retention interval of zero months and eight months was higher on the post-review test than on the end-of-course test in Algebra 2. However, the results of a dependent t-test showed the difference was statistically significant only for students with a retention interval of zero months (Table 13). Although the scores were not statistically significant, students with a retention interval of 12 months scored slightly lower (1.24) on the post-review test than on the end-of-course test in Algebra 2.

Table 13

Dependent t-test: End-of-Course Test in Algebra 2 and Post-Review Test

	RI = 0 months	RI = 8 months	RI = 12 months
Baseline EOC test: Algebra 2			
Mean	30.40	30.61	29.93
SD	4.81	4.06	4.37
Post-review test			
Mean	32.59	30.87	29.84
SD	4.26	4.34	5.32
t-value	-4.36	-0.87	2.04
2-tail sig.	.001***	0.39	.38

p = < .05* < .01 ** < .001 ***

On the post-review test of the performance-based assessment, a one-way analysis of variance was used to determine if a statistically significant difference existed in the means of the scores on the performance-based assessment among the three groups by retention interval. The results showed no statistically significant difference in the means of the groups by retention interval (Table 12). The statistical hypothesis was accepted. For none of the groups was the mean a proficient score (3.0 - 4.0), a standard set by the school district.

Research Question #3

Is there a significant difference in scores on an end-of-course test in precalculus among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months) before entering the precalculus course?

Statistical hypothesis: There is no statistically significant difference in the means on an end-of-course test in precalculus among three groups of students identified by the length of the retention interval before entering the precalculus course.

A one-way analysis of variance and Scheffé test were done to find if there was a statistically significant difference in the means on the end-of-course test in precalculus among the three groups by retention interval on the multiple choice component of the end-of-course test. The data are presented in Table 12. The data in Table 12 show no significant difference in the means of the end-of-course test among the three groups of students by retention interval. The statistical hypothesis was accepted on the multiple choice component of the end-of-course test in precalculus.

The one-way analysis of variance and Scheffé test were also done for the performance-based assessment on the end-of-course test in precalculus. The analysis showed no statistically significant difference in the means on the performance-based assessment among the three groups of students by retention interval (Table 12). The statistical hypothesis was accepted for the performance-based assessment of the end-of-course test in precalculus. The mean of students with a retention interval of zero months and 12 months was at a proficient level (3.0 - 4.0), a standard set by the school district. The mean for no group was at a proficient level on the pre-review or on the post-review performance-based assessments.

Data Analysis for Research Questions 4, 5, and 6

A one-way analysis of variance and Scheffé test were done to analyze the data to answer research questions four, five, and six. The results are shown in Table 14 and indicate the effect of varying retention intervals on precalculus-merit students.

Table 14

Mean Scores by Retention Interval: Precalculus-Merit Students

	0 months	8 months	12 months	F-value
Baseline Algebra 2, end-of-course	27.14	28.40	24.33*	3.71
Pre-Review				
MC	26.14	19.73****	19.00****	11.14
PBA	2.41	2.10	1.90	1.16
Post-Review				
MC	30.43	27.85	25.82*	3.24
PBA	2.71	2.20	1.80	3.03
Precalculus, end-of-course				
MC	25.86	22.47	25.50	1.19
PBA	2.68	2.47	2.34	.59

p = < .05* < .01 ** < .001 *** < .0001 ****

Research Question #4

Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-merit students identified by the length of the retention interval.

The results of the one-way analysis of variance and the Scheffé test on the multiple choice component of the pre-review test showed a significant difference in the means between students with a retention interval of zero months and eight months and between students with a retention interval of zero months and 12 months. No significant difference was found in the means between students with a retention interval of eight months and 12 months (Table 14). The statistical hypothesis was rejected for students with a retention interval of zero months and eight months and between students with a retention interval of zero months and 12 months. The statistical hypothesis was accepted between students with a retention interval of eight and 12 months.

The results of the one-way analysis of variance and the Scheffé test on the performance-based assessment showed no significant difference among any of the three groups by retention interval (Table 14). The mean for no group was at a proficient level (3.0 - 4.0). The statistical hypothesis was accepted.

Research Question #5

Is there a significant difference in the scores of precalculus-merit students on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the scores of precalculus-merit students on a post-review test given at the end of the teacher review of approximately four weeks.

The results of a one-way analysis of variance and the Scheffé test showed a significant difference in the means between students with a retention interval of zero months and 12 months (Table 14) on the multiple choice component of the post-review test. No significant difference in the means was found between students with a retention interval of zero months and eight months or between students with a retention interval of eight months and 12 months. The statistical hypothesis was rejected for students with a retention interval of zero months and 12 months. The statistical hypothesis was accepted for students with a retention interval of zero months and eight months and for students with a retention interval of eight months and 12 months.

On the performance-based assessment of the post-review test, the results of the one-way analysis of variance and the Scheffé test showed no significant difference among any of the three groups of precalculus-merit students by retention interval (Table 14). The statistical hypothesis was accepted.

Research Question #6

Is there a significant difference in the scores on an end-of-course test in precalculus among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the means on an end-of-course test in precalculus among three groups of precalculus-merit students identified by the length of the retention interval.

The results of a one-way analysis of variance and Scheffé test showed no significant difference in the means of scores on the multiple choice component of an end-of-course test in precalculus among any of the three groups of students by retention interval (Table 14). Likewise, no significant difference was found in the means of the scores on the performance-based assessment among any of the three groups of students by retention interval (Table 14). The statistical hypothesis was accepted for both the multiple choice component and the performance-based assessment.

Data Analysis for Research Questions 7, 8, and 9

A one-way analysis of variance and Scheffé test were done to answer the research questions regarding the effect of varying retention intervals on precalculus-honors students. The results of the data analysis are shown in Table 15.

Table 15

Mean Scores by Retention Interval: Precalculus-Honors Students

	0 months	8 months	12 months	F-value
Baseline Algebra 2, end-of-course	32.61	31.21	32.45	1.48
Pre-Review				
MC	32.61	24.22****	22.64****	45.44
PBA	2.84	2.24	2.42	2.95
Post-Review				
MC	34.10	32.03	31.29**	5.28
PBA	3.10	2.61	2.95	2.36
Precalculus, end-of-course				
MC	31.48	31.97	31.85	.16
PBA	3.35	3.04	3.36	1.56

p = < .05* < .01 ** < .001 *** < .0001 ****

Research Question #7

Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-honors students identified by the length of the retention interval.

The results of the one-way analysis of variance and the Scheffé test on the multiple choice component of the pre-review test showed a significant difference in the means between students with a retention interval of zero months and eight months and between students with a retention interval of zero months and 12 months. No significant difference was found in the means between students with a retention interval of eight months and 12 months (Table 15). The statistical hypothesis was rejected for students with a retention interval of zero months and eight months and between students with a retention interval of zero months and 12 months. The statistical hypothesis was accepted between students with a retention interval of eight months and 12 months.

The results of the one-way analysis of variance and the Scheffé test on the performance-based assessment showed no significant difference among any of the three groups by retention interval (Table 15). The mean for no group was at a proficient level (3.0 - 4.0). The statistical hypothesis was accepted.

Research Question #8

Is there a significant difference in the scores on a post-review test given at the end of the teacher review of approximately four weeks among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the scores of precalculus-honors students on a post-review test given at the end of the teacher review of approximately four weeks.

The results of a one-way analysis of variance and the Scheffé test showed a significant difference in the means between students with a retention interval of zero months and 12 months (Table 15) on the multiple choice component of the post-review test. No significant difference in the means was found between students with a retention interval of zero months and eight months or between students with a retention interval of eight months and 12 months. The statistical hypothesis was rejected for students with a retention interval of zero months and 12 months. The statistical hypothesis was accepted for students with a retention interval of zero months and eight months and for students with a retention interval of eight months and 12 months.

On the performance-based assessment of the post-review test, the results of the one-way analysis of variance and the Scheffé test showed no significant difference among any of the three groups of precalculus-honors students by retention interval (Table 15). The statistical hypothesis was accepted.

Research Question #9

Is there a significant difference in the scores on an end of-course test in precalculus among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

Statistical hypothesis: There is no statistically significant difference in the means of scores on an end-of-course test in precalculus among three groups of precalculus-honors students identified by the length of the retention interval.

The results of a one-way analysis of variance and Scheffé test showed no significant difference in the means of scores on the multiple choice component of an end-of-course test in precalculus among any of the three groups of students by retention interval (Table 15). Likewise, no significant difference was found in the means of the scores on the performance-based assessment among any of the three groups of students by retention interval (Table 15). The statistical hypothesis was accepted for both the multiple choice component and the performance-based assessment.

Research Question #10

What instructional strategies are used by teachers to review Algebra 2 skills/concepts so that students can reacquire previously learned skills/concepts that may have been lost during the retention interval?

A qualitative research method, specifically classroom observations, was used to answer this question.

Demographics: Teacher Participants

The sample (n = 4) of teachers was comprised of all teachers of precalculus for the second semester in the two schools involved in the study. Two of the four teachers, one male and one female, at each of the two schools, taught the precalculus-honors course. Three of the four teachers, one at School B and two at School A, taught the precalculus-merit course. The sample of teachers, all Caucasian, was comprised of four certificated mathematics teachers, with three of the teachers, one female and two males, having twenty or more years of experience. One female teacher had five years of experience. All teachers in the sample had test administration experience of five years or more with the end-of-course test used in the study (Table 16).

Table 16

Characteristics of Teacher Participants

Gender	Race	Certificated in Mathematics	Years of Teaching Experience	Years of Testing
Female	White	Yes	20+	5+
Male	White	Yes	20+	5+
Male	White	Yes	20+	5+
Female	White	Yes	5+	5

Teacher participants were observed on alternate days, School A one day, School B the next, until all had completed their review of Algebra 2 skills/concepts. At School A, 17 observations of approximately 90 minutes each were done for a total of 1,496 minutes (24 hours, 56 minutes). At School B, 18 observations were done for a total of 1,544 minutes (25 hours, 44 minutes) (Table 17).

Table 17

Record of Classroom Observations

	No. of Observations	No. of Minutes	No. of Hours
School A			
Teacher #1	11	942	15 h 42 min
Teacher #2	6	554	09 h 04 min
School B			
Teacher #1	9	751	12 h 31 min
Teacher #2	9	793	13 h 13 min
Total	35	3,040	50 h 40 min

Teacher participants varied in the number of days they took to review the Algebra 2 skills/concepts. Teacher #1 at School A took the longest time to review (22 days) while Teacher #2 at School A reviewed for the shortest period of time (15 days). Teachers at School B reviewed only one and two days less than Teacher #1 at School A (Table 18).

Table 18

Length of Review Period by Teacher

	Level	
	Honors	Merit
School A		
Teacher # 1	22 days	22 days
Teacher #2		15 days
School B		
Teacher # 1	21 days	
Teacher #2		20 days

Instructional strategies observed were separated into three major categories of activities: explanation, application, and synthesis. Instructional strategies were timed to determine the amount of class time used for a particular activity (Appendix D).

Explanation activities were defined as those activities done by teachers for many years in a traditional schedule. Teachers were usually in front of the class using a chalkboard or overhead projector to explain what students were to learn. This was the instructional phase of the lesson and included elements of Hunter's (1982) lesson design, such as identifying objectives, specifying the tasks to be completed, and demonstrating how to successfully complete the objectives. Student/teacher interactions varied during this phase of activities. In the second category, application activities, students should become more active learners and have opportunity to apply the skills and concepts covered in the explanation phase (Canady & Rettig, 1995). The third category of instructional strategies were synthesis activities. During this phase, teachers were to involve students in connecting the explanation part of the lesson with the application phase. This was a time when teachers were to provide time for reflection, review, reteaching, and closure.

The results of the classroom observations for all teachers showed a great emphasis on explanation, followed by application, with no use of the synthesis activities described by Canady and Rettig (1995).

Teacher #1, School A, was observed 11 times for a total of 942 minutes (15 hours, 42 minutes). Although this teacher acted more as a facilitator of learning, 61.5% of the classroom time was used on explanation activities with 18% of this time being in a lecture/discussion format. During the lecture/discussion, this teacher actively engaged students in the lesson. Often, the students were at the chalkboard or overhead projector explaining a solution to a problem to the rest of the class while the teacher evaluated the solution from the back of the classroom. Only once during the observations did the teacher conduct a lecture without asking for student input. This same model, students putting the solution on the board and explaining it, was used when the teacher and students discussed the answers to the warm-up activity or homework.

Teacher #1, School A, used 38% of the classroom time on application activities. However, the application activities were those identified as strategies observable in the traditional mathematics class; group work, guided practice, independent practice, quizzes/tests, and homework. When students worked in groups, the assignment to groups was done very informally with students self-selecting with whom they would work. The guided practice activities were led by the teacher and followed by independent practice or a homework activity. This teacher used 20% of the observed time giving tests or quizzes. These varied from homework quizzes lasting only a few minutes to tests lasting for nearly the full classroom period. There was no evidence of the use of application of knowledge strategies named in the literature as more appropriate in a block schedule; computer use, problem solving, interdisciplinary activities, or cooperative learning.

Teacher #1, School A, showed no use of synthesis strategies, except for management tasks in the assignment of homework. There was no review of the lesson/activities, no reteaching, and no closure to the lessons.

A complete analysis of the instructional activities used by Teacher #1, School A, and the time allotted to each is shown in Table 19.

Table 19

Teacher #1: School A, Instructional Activities

Strategy	Total Minutes	Percent of Observed Time
Explanation		
Warm-up	74	8
Discussion of warm-up	77	8
Discussion of homework	219	23
Lecture/discussion	173	18
Other		
Review of quiz	10	1
Review for test	5	.5
Transition activities	10	1
Management activities	22	2
Total	590	61.5
Application		
Group work	7	1
Guided practice	88.5	9
Independent practice	23	2
Work on homework	41	4
Tests/quizzes	186	20
Total	346	38
Synthesis		
Management tasks	6	.5
Total	942	100

Teacher #2, School A, was observed six times for 554 minutes (9 hours, 14 minutes). The instructional strategies used reflected a very traditional use of instructional time and pedagogy during the review period. Teacher #2 used 61% of the observed time in explanation activities with 40% of it being a lecture/discussion format. The lecture was teacher-centered with little to no input from the students and followed a warm-up activity. The warm-up activity was in a quiz format. Students began the warm-up quiz immediately upon entering the room, copying the problems from the overhead projection. The teacher led a discussion of the problem solutions, then collected the quiz results.

Teacher #2, School A, used 36% of the observed time on application activities. However, like Teacher #1, the application activities were of a traditional scope: independent practice, work on homework, and quizzes/tests. Independent practice (13%) and tests/quizzes (17%) consumed much of the time used in application activities. The independent practice was often one or more worksheets for the students to complete, with little to no follow-up to the work completed. Students did not have opportunities to work in small groups, neither did they have structured guided practice before beginning the independent practice. Again, there was no evidence of the use of strategies requiring an application of knowledge named in the literature as more appropriate for a block schedule: computer use, interdisciplinary activities, problem solving, cooperative learning, or group work.

Except for management activities, Teacher #2 did not demonstrate the use of synthesis activities. Management activities were assigning homework or reminding students of upcoming assignments. In one instance, students were given time to study for a test.

A complete analysis of the instructional activities used by Teacher #2, School A, and the time allotted to each are shown in Table 20.

Table 20

Teacher #2: School A, Instructional Activities

Strategy	Total Minutes	Percent of Observed Time
Explanation		
Warm-up	42	8
Discussion of warm-up	48	9
Discussion of homework	21	4
Lecture/discussion	223	40
Other		
Management activities	2	.4
Total	336	61
Application		
Independent practice	74	13
Work on homework	31	6
Tests/quizzes	95	17
Total	200	36
Synthesis		
Management tasks	8	1
Other		
study for test	10	2
Total	18	3
Grand Total	554	100

Like the teachers at School A, teachers at School B also used traditional strategies during the observed lessons. Teacher # 1, School B, was observed nine times for 751 minutes (12 hours, 31 minutes). Teacher # 1, School B, used 53% of the observed time for the explanation phase of the lesson with 26% of this spent on lecture/discussion. The lecture was teacher-centered with little input from the students. When there was student participation, only a small percentage of the class members

Table 21

Teacher #1: School B, Instructional Activities

Strategy	Total Minutes	Percent of Observed Time
Explanation		
Statement of objectives	1	0
Warm-up	25	3
Discussion of warm-up	41	6
Discussion of homework	108	14
Lecture/discussion	198	26
Other		
Management activities	30	4
Total	403	53
Application		
Group work	156	21
Guided practice	19	3
Independent practice	24	3
Work on homework	48	6
Tests/quizzes	99	13
Total	346	46
Synthesis		
Management tasks	2	.3
Total	2	.3
Grand Total	751	99.3

Teacher #2, School B, was observed nine times for 793 minutes (13 hours, 13 minutes). Similar to the others, this teacher used a large portion of the observed time (60%) on explanation activities. Students were actively engaged (50% or more) in the discussion of the homework which comprised 18% of the time used in explanation. Students either placed the solutions to the homework problems on the board or gave the answer when asked by the teacher. In approximately one-third of the lecture/

discussions, the lecture was teacher-centered with the teacher writing notes on the overhead projector and the students copying the notes. When the teacher lectured with more of a lecture/discussion approach, a large percentage of the students, ranging from 50% to 100% of the students, gave input.

Teacher #2, School B, used 39% of the observed time on application activities. Again, the activities were generally those associated with traditional instruction in mathematics; informal group work, guided practice, independent practice, work on homework, and tests/quizzes. When assigned group work, the students self-selected the members of their group, typically working in groups of four. Teacher #2, School B, did use one problem solving activity during one of the observations. In this activity, students were asked to find the rule for cubics, quartics, and quintics.

Like the other three teachers in the study, Teacher #2, School B, used no synthesis activities, except for management tasks (preparing to leave the classroom at the end of the period). There was no review of the lesson activities, reteaching, or closure.

An analysis of the instructional strategies used by Teacher #2, School B, is shown in Table 22.

Table 22

Teacher #2: School B, Instructional Activities

Strategy	Total Minutes	Percent of Observed Time
Explanation		
Warm-up	94	11
Discussion of warm-up	43	5
Discussion of homework	145	18
Lecture/discussion	154	19
Other		
Management activities	12	2
Review of practice test	29	4
Transitions	8	1
Total	485	60
Application		
Problem Solving	24	3
Group work	103	13
Guided practice	51	6
Independent practice	10	1
Work on homework	73	9
Tests/quizzes	70	9
Total	307	39
Synthesis		
Management tasks	1	0.1
Total	1	0.1
Grand Total	793	99.01

When pooling all observations, 35 classroom observations were done for a total of 3,040 minutes (50 hours, 40 minutes). Two-thirds of the observed time was used for explanation activities; one-third of the time was used for application activities; and less than 1% of the time was used for synthesis activities (Table 23).

Table 23

Summary of Observations and Strategies

Strategy Used	Time in Minutes	Percent of Observed Time
Explanation	1,814	60
Application	1,199	39
Synthesis	27	1
Total	3,040	100

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter begins with an overview of the study which includes the research questions and methodology. Next, a summary of the study's major findings is presented. The chapter examines conclusions in five areas: the effect of varying retention intervals within a 4 X 4 block schedule on knowledge retention in mathematics, the effect of teacher review on the reacquisition of mathematics skills/concepts, the effect of varying retention intervals on students' knowledge retention by ability group, the effect of varying retention intervals on academic performance in a subsequent mathematics course, and finally, the instructional strategies used by classroom teachers during the review of previously learned skills/concepts so that students can reacquire those skills/concepts. Finally, some recommendations for further research are presented.

Overview of the Study

With the opening of the 1996-97 school year, it is estimated that more than 40% of the high schools in the United States will be using some variation of a block schedule. The 4 X 4 block schedule is a variation in which students take four courses for 18 weeks, one semester, completing all courses within the semester. This schedule allows students to complete eight Carnegie credits per school year, as opposed to the traditional six or seven. There are many advantages to the block schedule; changes in instructional pedagogy, specific advantages to teachers and students, and improvement in the school climate. However, because the 4 X 4 block schedule often requires students to "skip" one or more semesters between courses, critics of the 4 X 4 block schedule question the effect of the longer period of time than the traditional three month summer break on knowledge retention, especially in mathematics. This study examined the effect of varying retention intervals within a 4 X 4 block schedule on knowledge retention.

The purpose of the study was to examine the effect of varying retention intervals within a 4 X 4 block schedule on knowledge retention of mathematics skills/ concepts, specifically Algebra 2 skills/concepts, for students having a retention interval of zero months, 8 months, and 12 months. The study also examined the reacquisition of mathematics skills/concepts by the students who showed a retention loss after a period of review by the classroom teacher. Third, the study examined the effect of a lengthened retention interval on achievement in the subsequent mathematics course, precalculus-honors and precalculus-merit. Finally, because students enter a mathematics course with varying retention intervals, the study examined qualitatively the instructional strategies used by teachers to eliminate the effect of the retention interval for all students beginning a new course of mathematics study. The following research questions were explored:

1. Is there a significant difference in scores on a pre-review test given at the beginning of a precalculus course among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
2. Is there a significant difference in scores on a post-review test given at the end of the teacher review of approximately four weeks among three

groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

3. Is there a significant difference in scores on an end-of-course test in precalculus among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months) before entering the precalculus course?
4. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
5. Is there a significant difference in the scores of precalculus-merit students on a post-review test given at the end of the teacher review of approximately four weeks among three groups of students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
6. Is there a significant difference in the scores on an end-of-course test in precalculus among three groups of precalculus-merit students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
7. Is there a significant difference in the scores on a pre-review test given at the beginning of a precalculus course among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?
8. Is there a significant difference in the scores on a post-review test given at the end of the teacher review of approximately four weeks among

three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

9. Is there a significant difference in the scores on an end of-course test in precalculus among three groups of precalculus-honors students identified by the length of the retention interval (Group 1, zero months; Group 2, eight months; Group 3, 12 months)?

10. What instructional strategies are used by teachers to review Algebra 2 skills/concepts so that students can reacquire previously learned skills/concepts that may have been lost during the retention interval?

This study was conducted in two suburban high schools in a mid-Atlantic public school district. The sample was 172 students who were enrolled in precalculus-honors or precalculus-merit during the second semester of the school year. The sample also included four classroom teachers of precalculus. Both quantitative and qualitative methodologies were used in the study. Quantitative methods were used to answer the first nine research questions on the effect of varying retention intervals within a 4 X 4 block schedule on knowledge retention. Qualitative methods were used to answer the last research question on strategies used during review for students to reacquire previously learned skills/concepts.

The dependent variable for the first major research question was knowledge retention as measured on an end-of-course test in Algebra 2, a pre-review test, and a post-review test. The independent variables for the research questions were time as indicated by retention interval, Functional Mathematics Test Score, ability group, final grade in Algebra 1 and Algebra 2, and student characteristics: socioeconomic status, race, gender, and school.

The research question on strategies used by teachers during review for students to reacquire previously learned skills/concepts involved classroom observations of the teachers in the study. A checklist of categories of instructional strategies was designed by the researcher, and based on instructional strategies appropriate for the 4 X 4 block schedule as identified by Canady and Rettig (1995).

For the purposes of this study, the end-of-course tests in Algebra 2 and precalculus were selected as the testing instruments because scores on these tests are used by the school district to measure its effectiveness. The end-of-course test was composed of a 37-item multiple choice component and a performance-based assessment. End-of-course test scores on the multiple choice component were available for all students having completed Algebra 2 in the school district of the study. These scores were used as the baseline data. End-of-course scores were not available for the performance-based assessment for students with a retention interval of eight months and twelve months. At the beginning of the precalculus course, students repeated the same multiple choice component of the end-of-course test in Algebra 2 and completed one performance-based assessment with which the students were not familiar. These scores were used as pre-review test data. At the conclusion of the review of Algebra 2 skills/concepts, the same multiple choice component was given and a different version of the same performance-based assessment. These scores were used as post-review test data. Finally, scores on the multiple choice component and performance-based assessment component of the end-of-course test in precalculus were analyzed to find the effect of lengthened retention intervals on achievement in a subsequent mathematics course. In addition to the testing for the quantitative part of the study, classroom observations were done while teachers reviewed Algebra 2 skills/ concepts. Because of conflicts in schedules, it was not possible to observe all teachers in the study on the same day. Therefore, teachers were observed on alternate days for the full length of the period, 88 - 90 minutes. Observations of a given teacher were terminated after the post-review test was given by that teacher.

In the analysis of the research questions for the quantitative component of the study, descriptive statistics, including percentages and means where appropriate, were calculated and reported for the (a) dependent variable of knowledge retention as measured by the score on a end-of-course test; (b) independent variables of retention interval, Functional Mathematics Test score, ability group, final grade in Algebra 1 and Algebra 2, and student characteristics: socioeconomic status, race, gender, and school; and (c) student performance on the end-of-course test in Algebra 2 and precalculus, the pre-review test (multiple choice and performance-based assessment), and the post-review test (multiple choice and performance-based assessment).

To determine statistical significance of differences in test scores, a series of statistical analyses were used: one-way analysis of variance, Scheffé test, dependent t-tests, and independent-t tests.

In the analysis of the research question on instructional strategies used during review, data were organized and coded into three major categories: explanation, application, and synthesis, with sub-headings under each of these. The amount and percentage of time used on each strategy was calculated.

Summary of Major Findings and Conclusions

This section presents the study's major findings concerning the effect of varying retention intervals on knowledge retention in mathematics and the strategies used by classroom teachers to review previously learned skills/concepts.

The Effect of Varying Retention Intervals on Knowledge Retention

Pre-Review Test. The pre-review test was given to students on the first day of the precalculus course. The pre-review test consisted of two components, a multiple choice component and a performance-based assessment. On the multiple choice component, the analysis of the data showed a significant difference in the means between students with a retention interval of zero months and eight months and zero months and 12 months. There was no significant difference in the means between students with a retention interval of eight and 12 months. On the performance-based assessment, the analysis of the data showed no significant difference in the means among any of the groups by retention interval.

The students with a retention interval of zero months were given the multiple choice component of the pre-review test approximately one week after their completion of the Algebra 2 course. The means of students with a retention interval of zero months were significantly higher than the mean of students with a retention interval of eight months or 12 months. The mean of students with a retention interval of eight months did not reflect an advantage over students with a retention interval of 12 months. Although not statistically significant, the means of students with a retention interval of 12 months were slightly higher than the means of students with a retention interval of eight months. The longer retention interval (12 months compared to eight months) appeared to have no greater effect on the knowledge retention of Algebra 2 skills/concepts than did the shorter retention interval.

On the performance-based assessment, the length of the retention interval had no greater effect on one group of students than another on the skills/concepts tested. The mean scores were nearly the same for all groups of students by retention interval. The mean for no group was at a proficient level (3.0 - 4.0).

Post-Review Test. A post-review test was given to students in the study approximately four weeks after the beginning of the precalculus course and after teachers completed a review of Algebra 2 skills/concepts. The post-review test had two components, a multiple choice component and a performance-based assessment. The analysis of the data on the multiple choice component of the post-review test showed a significant difference in the means between students with a retention interval of zero months and 12 months. No significant difference in the means was found between students with a retention interval of zero and eight months or between students with a retention interval of eight months and 12 months. On the performance-based assessment, the analysis showed no significant difference in the means among any of the groups by retention interval on the performance-based assessment. The mean of no group by retention interval was at a proficient level (3.0 - 4.0).

On the multiple choice component, all students improved their scores overall during the four weeks of review of Algebra 2 skills/concepts. Students with a retention interval of eight and 12 months had the greatest gain. Students with a retention interval of zero months had some gain, but less than students with retention intervals of eight and 12 months. A significant gain was made for those for whom the retention interval was greater. Thus, students with a retention interval of eight months and 12 months reacquired the skills/concepts lost during the retention interval, and neither had a significant advantage over the other. Although not significantly different, scores of students with a retention interval of eight months made a greater gain (30.87) during the teacher review than did students with a retention interval of 12 months (29.84).

On the performance-based assessment, there was some increase in the mean for all three groups by retention interval, but the mean for no group was at a proficient level (3.0 - 4.0). Although the skills/concepts tested on the performance-based assessment were also tested on the multiple choice component, the reacquisition of skills/concepts shown on the multiple choice component was not reflected by the means on the performance-based assessment. The performance-based assessment required students to apply skills/concepts using a problem-solving approach rather than a simple solution as presented in a multiple choice format.

End-of-Course Test: Precalculus. At the end of the course in precalculus, a final test was given to all three groups by retention interval. The end-of-course test consisted of a multiple choice component and a performance-based assessment. On the multiple choice component, the data analysis showed no significant difference in the mean among any of the groups by retention interval. On the performance-based assessment, there was no significant difference in the means among any of the groups by retention interval.

With whatever advantage in knowledge of skills/concepts with which the students with a retention interval of zero months entered the precalculus course, the advantage was not maintained throughout the course of study in precalculus. Their achievement leveled off when exposed to the same instruction over the course of the semester as the students with a retention interval of eight months and 12 months. Similarly, the lengthened retention interval of eight months and 12 months had no significant effect on the performance of students in these groups on the end-of-course test in precalculus. Although not significant, the mean of students with a retention interval of 12 months was higher than the mean for students with a retention interval of zero months and eight months. On the performance-based assessment, there was no significant difference in the means among the three groups by retention interval. However, the means of students with a retention interval of zero months and 12 months were at a proficient level (3.0 - 4.0).

The Effect of Varying Retention Intervals on Precalculus-Merit Students

Pre-Review Test. The pre-review test was given to students on the first day of the precalculus course. The pre-review test consisted of two components, a multiple choice component and a performance-based assessment. On the multiple choice component, the data analysis showed a significant difference between students with a retention interval of zero months and eight months and between students with a retention interval of zero months and 12 months. On the performance-based assessment, there was no significant difference in the means among the three groups by retention interval. The mean of no group was at a proficient level (3.0 - 4.0).

The effect of varying retention intervals on precalculus-merit students was consistent with the effect on the total sample of students. Students with a retention interval of zero months entered the precalculus course with more knowledge of Algebra 2 skills/concepts than did students with a retention interval of eight months or 12 months. Students with a retention interval of eight months and 12 months lost a significant amount of knowledge during their respective retention interval. The mean on the multiple choice component was lower for precalculus-merit students than the mean for the total sample. On the performance-based assessment, the mean of no group of students by retention interval was at a proficient level (3.0 - 4.0). The length of the retention interval had no greater effect on one group than another on this component of the pre-review test.

Post-Review Test. After a four-week review period of Algebra 2 skills/ concepts, a post-review test was given to students in the study. The post-review test consisted of two components, a multiple choice component and a performance-based assessment. On the multiple choice component, the data analysis showed a significant difference in the means on the multiple choice component of the post-review test between students with a retention interval of zero months and 12 months. There was no significant difference in the means between students with a retention interval of zero and eight months or between eight months and 12 months. On the performance-based assessment, there was no significant difference in the means among any of the groups by retention interval. The mean of no group was at the proficient level (3.0 - 4.0).

Students with a retention interval of zero months appeared to have gained additional knowledge in the skills/concepts tested on the multiple choice component during the four weeks of review. Thus, they improved upon their advantage over students with a retention interval of eight months and 12 months. The gains made by students with a retention interval of eight months were on par with students with a retention interval of zero months. Students with a retention interval of 12 months reacquired the knowledge lost during the retention interval, but there remained a significant difference between students with a retention interval of zero months and 12 months. This was also true for the total sample. On the performance-based assessment, the mean of students in no group by retention interval showed a reacquisition of the skills/concepts tested on the performance-based assessment. The mean of no group was at a proficient level (3.0 - 4.0).

End-of-Course: Precalculus. A final test was given in precalculus at the end of the course. The end-of-course test consisted of a multiple choice component and a performance-based assessment. By the end of the precalculus course, there was no significant difference in the mean among any of the groups by retention interval on the multiple choice component of the end-of-course test in precalculus. However, the mean of students with a retention interval of zero months and 12 months was higher than the mean of students with a retention interval of eight months. On the performance-based assessment, there was no significant difference in the means among any of the groups by retention interval on the performance-based assessment.

As was true for the total sample of students, through the course of the semester, students with a retention interval of zero months lost the knowledge advantage with which they entered the precalculus course and had at the end of the teacher review. Students with a retention interval of zero months scored similarly (25.86) to students with a retention interval of 12 months (25.80). The lengthened retention interval of eight months or 12 months had no significant effect on the performance of students on the multiple choice component of the end-of-course test in precalculus.

On the performance-based assessment, the mean of no group of students by retention interval was at the proficient level (3.0 - 4.0).

The Effect of Varying Retention Intervals on Precalculus-Honors Students

Pre-Review Test. As was true for the total sample and for precalculus-merit students, the data analysis on the multiple choice component of the pre-review test showed a significant difference in the means between students with a retention interval of zero months and eight months and between students with a retention interval of zero months and 12 months. On the performance-based assessment, there was no significant difference among any of the three groups by retention interval.

Students with a retention interval of zero months entered the precalculus course having more knowledge of the Algebra 2 skills/concepts tested on the multiple choice component than did students with a retention interval of eight months or 12 months. While the overall mean was higher, students with a retention interval of eight months had no significant advantage over students with a retention interval of 12 months. On the performance-based assessment, students in no group by retention interval had an advantage over another group on the skills/concepts tested on the performance-based assessment. The mean of no group was at a proficient level (3.0 - 4.0).

Post-Review Test. A post-review test was given at the end of the review of Algebra 2 skills/concepts of approximately four weeks. The post-review test consisted of a multiple choice component and a performance-based assessment. On the multiple choice component, the data analysis showed a significant difference in the means on the multiple choice component of the post-review test between students with a retention interval of zero months and 12 months. There was no significant difference in the means between students with a retention interval of zero and eight months and 12 months. On the performance-based assessment, there was no significant different in the means among any of the three groups by retention interval. The mean of no group was at a proficient level (3.0 - 4.0).

Students with a retention interval of zero months appeared to gain additional knowledge of the skills/concepts tested on the multiple choice component of the post-review test given after four weeks of review. Students with a retention interval of eight months and 12 months reacquired the knowledge of Algebra 2 skills/concepts lost during the retention interval.

Students with a retention interval of zero months gained knowledge of the skills/concepts tested on the performance-based assessment. Students in this group scored at a proficient level (3.0 - 4.0). On the performance-based assessment, the mean of all groups was higher on the post-review test than on this same component of the pre-review test.

End-of-Course: Precalculus. At the end of the course in precalculus, a final test was given to all three groups. The end-of-course test consisted of two components, a multiple choice component and a performance-based assessment. The data analysis showed no significant difference in the means among the three groups by retention interval on either the multiple choice component or the performance-based assessment of the end-of-course test in precalculus.

The advantage with which students with a retention interval of zero months entered the precalculus course and which was present at the end of the teacher review of four weeks was not maintained throughout the course of study of precalculus. Although not significant, the mean of precalculus-honors students with a retention interval of zero months was lower than for students with a retention interval of eight months or 12 months. There was no significant effect of the lengthened retention interval of eight months and 12 months on the performance on the end-of-course test in precalculus. On the performance-based assessment, students in all groups by retention interval scored at a proficient level (3.0 - 4.0). This was not true for the total sample or for precalculus-merit students.

Strategies Used by Teachers to Review Algebra 2 Skills/Concepts

The strategies used by teachers to review Algebra 2 skills/concepts were identified as primarily traditional in scope, with a heavy emphasis on explanation activities. Teachers used 60% of the observed time in explanation activities, 39% of the time in application activities, and only 1% of the time in synthesis activities. There was no evidence of the instructional activities named in the literature which can be used in the 4 X 4 block schedule, such as computer use, problem solving, interdisciplinary activities, or cooperative learning, that create advantages to instruction not possible in the traditional schedule.

Discussion of the Conclusions

The conclusion that the mean of students with a retention interval of eight months did not reflect an advantage over students with a retention interval of 12 months is consistent with research by Semb, Ellis and Araujo (1993) which showed that students retained after 11 months 80% of what they learned. Since students with a retention interval of zero months had only one week between the end-of-course test in Algebra 2 (baseline data) and the pre-review test, their knowledge retention was much higher than for students with a retention interval of eight months or 12 months. The conclusion is also consistent with the findings of Schuell and Giglio (1973). The analysis of the independent variables (final grades in Algebra 1 and Algebra 2 and scores on a functional mathematics test) in this study showed no significant difference in the knowledge retention between students with a retention interval of eight months and 12 months. Studies by Schuell and Giglio (1973) suggest that "forgetting rates" will be comparable if former achievement rates are equal. The conclusion by Schuell and Giglio is supported in studies by Conway, Cohen, and Stanhope (1991) which showed a rapid decline in knowledge retention after the first exposure, followed by a "leveling out" over time. This "leveling out" was supported by the results of this research since students with a retention interval of 12 months "forgot" no more than did students with a retention interval of eight months. Guskey and Kifer (1995) reported that teachers could discern little difference between students who had recently completed a prerequisite course and those with a longer time lapse between courses. This study showed no significant difference on the pre-review test scores between students with a retention interval of eight months and 12 months. However, there was a statistically significant difference in the means of the pre-review test scores of students with a retention interval of zero months and the scores of students with a retention interval of eight months and 12 months. This would indicate that perhaps teachers could discern a difference between students who had recently completed a course and those who had a lengthened retention interval.

The conclusion that the analysis of post-review test data indicated that students in all groups by retention interval were able to reacquire knowledge during the review of Algebra 2 skills/concepts not retained during the retention interval is supported by previous research studies. Smythe, Stennctt, and Rachar (1974) reported that although students with an extra semester off had more difficulty recalling previously learned concepts, they recovered quickly during the subsequent course. The findings of this study reflect such a recovery. The mean score for students with a retention interval of zero months or eight months was higher on the post-review test than on the pre-review test. This finding was important because as Spitzer (1939) and Musser (1993) noted, the improvement of skills and knowledge is dependent upon the learner's retention of previously learned skills and knowledge. In this study, for students to learn subsequent skills/concepts in precalculus, it was important they know previously learned skills/concepts in Algebra 2.

The conclusion that there was no difference for the total sample among students by retention interval on the performance-based assessment of the pre-review test and post-review test can be supported by Bahrick's research (1984) that showed knowledge retention can be predicted by the initial depth of learning. In this case, there was little difference between the pre-review test scores and the post-review test scores, and on neither test did students perform at a proficient level (3.0-4.0) on the performance-based assessment. This may have indicated a lack of knowledge of the skills/concepts being assessed although it was reviewed by the classroom teachers during the review period. It may also indicate an inability to apply previously learned concepts in problem-solving tasks. Studies by Bahrick (1975, 1984), Conway, Cohen, and Stanhope (1991), Semb, Ellis, and Araujo (1993), and Silver (1981) showed that students arc more likely to retain higher level knowledge and skills such as concepts than they are recall of facts. The reports by these researchers did not hold true for the students in this study. Students in this study performed better on the multiple choice component of tests which generally require more recall than they did on the performance-based assessments which require more application of concepts. The type of instruction may also have had an impact on student achievement on the performance-based assessment. This will be discussed further with the last conclusion.

The finding that the lengthened retention interval had no effect on the reacquisition of previously learned Algebra 2 skills/concepts on precalculus-merit students and precalculus-honors students is consistent with Bahrick's research (1984) which states that students retain knowledge and forget knowledge to the extent that they learned it initially. On the multiple choice component of the pre-review test and the post-review test, the significant differences in the means were between students with a retention interval of zero months and eight months and zero months and 12 months for both ability groups. This was also consistent with the reacquisition of skills/concepts for the total sample.

The conclusion that precalculus-honors and precalculus-merit students scored similarly on the performance-based assessment of the pre-review test and the post-review test and that only precalculus-honors students with a retention interval of zero months scored at a proficient level is inconsistent with the research of Silver (1991). Silver reported that high ability students are more likely to retain concepts and low ability students are more likely to recall information. In this study, precalculus-honors students were as unable to retain the skills/concepts tested on the performance-based assessment as were the precalculus-merit students. This research is consistent with Bahrick and Hall (1991) who suggested that retention losses were relatively unaffected by individual differences, such as aptitude, but instead were more influenced by variables such as curriculum and schedule of instruction.

The conclusion that students within each group by retention interval of the total sample and by ability level performed on the end-of-course test in precalculus similarly to each other on both the multiple choice component and the performance-based assessment is consistent with the findings of a 1994 study of North Carolina schools which showed that students' scores (on statewide tests) had neither increased nor decreased with the implementation of the block schedule. Spencer (1994) also reported insignificant differences in achievement for students on a block schedule.

It is important to note that students with a retention interval of zero months scored significantly higher on both the pre-review test and the post-review test than did students with a retention interval of eight months or 12 months. Although this may seem to have given these students an advantage toward greater achievement in precalculus, all students scored similarly on the end-of-course test in precalculus with no significant difference among the three groups by retention interval.

The conclusion that the instructional strategies observed during the teacher review of Algebra 2 skills/concepts were those associated with a traditional school schedule and not consistent with strategies named in the literature contradicts the work of other researchers who identify instructional innovations as one of the great advantages of a 4 X 4 block schedule. Two-thirds of the observed time was used for explanation activities; one-third of the time was used for application activities; and less than 1% of the time was used for synthesis activities. This is in contrast to what is reported in the literature as appropriate strategies for a 4 X 4 block schedule. Canady and Rettig (1995) propose that only 25-44% of the classroom time should be spent on explanation activities. The majority of the instructional time, 44-78%, should be spent on application activities that are different from the traditional activities observed in this study. Canady and Rettig (1995) contend that if the majority of the instructional time is not spent on application activities, retention of learning will be limited. Finally, Canady and Rettig (1995) assert that 15-33% of the instructional time should be spent on synthesis activities. In the classroom observations done for this study, synthesis activities, except for some minor management tasks ("don't forget to study," "don't forget to do your homework"), were non-existent. The use of more traditional instructional strategies with less emphasis on application and synthesis than what is recommended by Canady and Rettig may explain why students performed better on the multiple choice component of the post-review test than they did on the performance-based assessment. Traditional instruction favors traditional assessments, such as multiple choice assessments. In his review of literature on the block schedule, Kramer (1996) reported that mathematics teachers are less likely to change their teaching methods on a block schedule than are teachers of other subjects. The data in this study did not support the perception that block schedules force teachers to use more in-depth learning activities (Kadel, 1994; Kramer, 1996; O'Harrow & Bates, 1996). Although Meadows' study (1995) reported data from teachers of all subjects, the data of this study, gathered during classroom observations of mathematics teachers, did not support the findings of Meadows' study which reported that teacher perceptions are that they use a greater variety of activities, are more creative, plan more for in-depth lessons, allow more opportunities for critical thinking and deeper discussion, and more integration of subjects. Although students did work in informal groups during the application activities, there was no evidence of cooperative learning, a strategy reported as being used more extensively by teachers on a 4 X 4 block schedule (Hottenstein & Malatesta, 1993; Sadowski, 1996; Winans, 1997). Fleming (1997) and Schoenstein (1995) reported that teaching changes on a block schedule as teachers act more as facilitators of learning instead of a "deliverer of knowledge". One teacher in the study did use a facilitating approach, requiring students to perform the solution of problems for the class to observe; however, none of the teachers used the strategies named above.

The performance of students on the multiple choice component compared to the performance-based assessment may reflect the instructional pedagogy of the teachers. Multiple choice tests arc traditional in scope and parallel traditional instructional practices. On the contrary, performance-based assessments require students to problem solve and apply what has been learned to new situations. In this study, students did not perform to the level on the performance-based assessments that they did on the multiple choice component. This may be because teachers did not teach using strategies that required students to problem solve.

Recommendations for Future Research

This study added significantly to the body of empirical research on the block schedule. It is also one of only a few quantitative studies that address the question of knowledge retention in a 4 X 4 block schedule. The study has implications for (1) block scheduling, and (2) future research.

Implications for Block Scheduling

The results of this study showed that when teachers spend time reviewing the skills/concepts of the previous mathematics class, the effects of a lengthened retention interval (eight or 12 months) on knowledge retention are eliminated. However, a four-week period of review, which would be nearly a full grading term under the traditional schedule, decreases substantially the time available for students to learn in depth the skills and concepts of the mathematics course in which they are currently enrolled. Pre-testing the students, especially if the students in the class have varying retention intervals, may eliminate the need for such a lengthy review. Kramer (1997) notes that "if under a block schedule each topic requires more instructional time, less time is likely to be available for review of work from previous courses" (760). Also, Kramer (1997) points out that "if more in-depth instruction under a block schedule is associated with higher-order thinking and better problem-solving ability and retention, then less of a need for such a review is likely to exist" (760).

Students with a retention interval of zero months had a statistically significant difference in the means on the pre-review test and post-review test from students with a retention interval of eight months and 12 months. School administrators and teachers may consider scheduling alternatives so that these students are not mixed with students with longer retention intervals. If these students were in a class section with students having the same retention interval, the need for review would be eliminated. The time gained could be used to study more in depth the skills and concepts of the new course.

The qualitative component of this study showed teachers were using very traditional instructional strategies to review the skills and concepts of the previous course. School administrators and teachers must seek staff development opportunities for teachers to train them in more innovative and effective strategies. Fleming (1997) notes that a block schedule demands a greater repertoire of instructional strategies. Teachers have reported that training in cooperative learning, problem-centered learning, alternative assessments, project-based assignments, asking open-ended questions, using technology resources, and conducting classroom discussions have helped them in preparing to teach in a block schedule. In that the two schools in this study had been on a 4 X 4 block schedule for four and five years, the observations done in this study showed that changing to a block schedule does not guarantee change in instructional pedagogy.

Implications for Further Research

Researchers should address the long-term effect of a 4 X 4 block schedule on mathematics achievement as reflected in end-of-course test scores. One school in this study has shown a downward trend in mathematics test scores since the implementation of the 4 X 4 block schedule. In this school, the number of students achieving mastery (80%) on the end-of-course tests in mathematics has decreased from 48% in the last year of the traditional school schedule to 38% after four years on a 4 X 4 block schedule. These data should be disaggregated to find in what courses and with what students (by ability level and by retention interval) the decrease is occurring, and if there is a possible connection to instructional pedagogy.

One argument in favor of a 4 X 4 block schedule is the increased number of options it allows students to take more courses. Edwards (1995) reported that students often enroll in a larger number of core courses, and in particular a larger number of mathematics classes. Enrollment trends in mathematics should be studied to find if students in the school district are taking more mathematics courses than they did under the traditional schedule.

A study is needed using a control group of students with a retention interval of three months, the length of the traditional summer schedule. Opponents of the 4 X 4 block schedule argue that students will forget too much if they have a retention interval longer than three months. The results of this study did not show great differences in the post-review test scores of students with a retention interval of zero months over students with a retention interval of eight months or 12 months, but it did not have a control group of students with a retention interval of three months.

A researcher in a school system in the process of changing to a 4 X 4 block schedule could add to the body of knowledge on this topic by doing a study on knowledge retention of students in a school using a traditional schedule of year-long courses versus a school using a 4 X 4 block schedule.

Further research is needed to find the effects of a 4 X 4 block schedule on the knowledge retention of lower ability students in other mathematics courses. This study dealt with average to above average students in upper level mathematics courses.

Finally, further research is needed in urban and rural schools with more diversity among the student population. Although this study was done in two suburban schools that have diverse populations, the mathematics courses selected for study limited the diversity of the sample.

Appendix A

Letter of Permission

COUNTY PUBLIC SCHOOLS
115 EAST CHURCH STREET
MARYLAND 21701

Julian Katz
Manager of Measurement
and Statistical Analysis

Telephone
301-694-1365

July 12, 1996

Brenda P. Shockey
1590 Elmwood Court
:, MD 21702

A STUDY OF THE EFFECT OF BLOCK SCHEDULING ON MATH ACHIEVEMENT

The committee has reviewed your request for independent research within the County Public School system, and recommends that this project be approved.

JULIAN KATZ--MEASUREMENT AND STATISTICAL ANALYSIS MANAGER

JK:lg

Our Mission is Teaching for Quality Learning for All Students

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Appendix B

Guidelines for Teachers

Guidelines for Teachers

Since the implementation of block schedules began in the United States in the early 1990s, the literature on block schedules reflects a reoccurring question among parents and educators regarding the effect of block schedules, with courses meeting for 90 minutes per day for only one semester, on knowledge retention. This question has been especially prevalent for mathematics and foreign language. Students at your school who are in precalculus-honors and precalculus-merit classes for the second semester of the 1996-97 school year will be involved in a research study to determine the effects of a block schedule on knowledge retention in mathematics.

The researcher conducting this study is Brenda P. Shockey who is presently on a sabbatical leave from her position of middle school principal in the school district of this study to complete her doctoral studies at the University of Maryland. As a middle school principal, she is often asked by parents of eighth grade students about the effect of block schedules at the high school level on mathematics achievement. The study being done by the researcher will examine the effects of a block schedule on knowledge retention in mathematics.

At the end of the Algebra 2 course, all students took a district summative test with a multiple choice component and two performance-based assessments. Students who participate in this research study will take the multiple choice component of the Algebra 2 district summative test again on the first day of the second semester, January 28, 1997, in their precalculus course. On the second day of the precalculus course, January 29, 1997, students will take Version A of one performance-based assessment. After the teacher participant has completed the review of Algebra 2 skills/concepts, approximately four weeks later, the multiple choice component will be repeated along with Version B of the performance-based assessment. All assessments are part of the Criterion Referenced Evaluation System in the school district of this study. The multiple choice component of the district summative test will be the same multiple choice test taken at the end of the Algebra 2 study. The performance-based assessment will be like in design and concepts evaluated in a performance-based assessment taken at the end of the Algebra 2 course.

Student participation in this study is important to its success, but it is, of course, also completely voluntary. All student test results will be held strictly confidential and no student names will be used in the written report. A summary of results from the research study will be available in the school office in September, 1997. Parents of students enrolled in precalculus received a letter that described the research study and gave them an opportunity to withdraw their child from the study at any time.

Teacher Guidelines for Informing Students
About the Study

Teachers should describe the research study to students using the script below:

T: Students, I'd like to tell you about a research study in which you will have the opportunity to participate.

At the end of Algebra 2, you took the district summative test consisting of a multiple choice component and a performance-based component.

Since the implementation of the block schedule and the four-period day, a commonly asked question is, "What is the effect of a block schedule on knowledge retention in mathematics since students may "skip" one or more semesters between mathematics courses?" This research study will help answer this question.

T: Today, all students will take the multiple choice component of the district summative test. The score on this test will be compared to your score on the multiple choice component taken at the end of Algebra 2 to determine your knowledge retention of Algebra 2 skills/concepts.

T: Tomorrow, all students will take Version A of a performance-based assessment.

T: After I, the teacher, have completed all review of Algebra 2 skills/concepts, both components of the district summative test will be repeated, the multiple choice component and Version B of the performance-based assessment. The score of the multiple choice component will be compared to the score at the end of Algebra 2 to find if you have reacquired the skills learned in Algebra 2. The score on the performance-based assessment will be compared to the score on Version A to find if you have reacquired the concept evaluated in the assessment.

T: During the research study, and especially during the period of review of Algebra 2 skills/concepts, the researcher will be in the classroom on alternate days observing the strategies used by me for you to reacquire the Algebra 2 skills/concepts.

T: At the end of the semester, your score on the district summative test for precalculus will be compared to the score on the district summative test for Algebra 2 to determine if the "gap" between mathematics courses had an effect on your achievement in precalculus.

T: All test scores will be held strictly confidential.

S: What do my parents have to do if they want me to participate?

T: Nothing. All of you received a letter from the researcher in this study to give to your parents. All of you will participate in the research study unless your parents returned the form to the guidance department saying that you should not participate. However, all students will take all assessments, as directed by me, whether or not you are participating in the study.

T: Let me review again quickly. Today, you will take the multiple choice component of the district summative test for Algebra 2. Tomorrow, you will take Version A of a performance-based assessment. After I have completed the review of Algebra 2 skills/concepts, you will repeat the multiple choice component and Version B of the performance-based assessment. Scores will be analyzed statistically to determine the effects of the block schedule on knowledge retention.

Appendix C

Letter to Parents

January 10, 1997

Dear Parent/Guardian:

During the high school experience, your son/ daughter has taken classes on a block schedule of four class periods per day, with each class period lasting 90 minutes for one semester. Since the implementation of the block schedule in _________ County Public Schools and in high schools across the nation, a reoccurring question has been "What impact does skipping a semester or a year between mathematics courses have on student performance in the next mathematics course?" I am writing to you because I am a doctoral student at the University of Maryland, and I am doing a research study that will examine this question.

As a former science curriculum specialist in _________ County and as a middle school principal, I have been involved in many meetings with parents when questions about the block schedule and its effect on mathematics achievement have been raised. The study which I am doing will help answer some of these questions. I am currently on a sabbatical leave from _________ County Public Schools which is allowing me an opportunity to conduct the research study in this school system. The results of this research have great implications for school administrators, teachers, students, and parents.

My study will involve the following. At the end of the Algebra 2 study, all students took a school district summative test. This test consisted of 37 multiple choice items and two performance based assessments. The scores from the multiple choice component of the district summative test will serve as the baseline data for this research on that component. At the beginning of the precalculus course on January 28, 1997 (beginning of second semester), your child will repeat the same multiple choice summative test given at the end of Algebra 2. On January 29, 1997, your child will take Version A of a performance based assessment. The score on the multiple choice component will be compared to the test score at the end of Algebra 2 to find if the gap in instruction had an effect on the retention (remembering) of Algebra 2 skills/concepts. Approximately two-four weeks after the beginning of the Algebra 2 course, and after the teacher has completed the review of Algebra 2 skills/concepts, the summative test will be repeated. This score will also be compared to the score at the end of Algebra 2 to determine if students have reacquired the skills/concepts they had at the end of Algebra 2. During the first two-four weeks of the semester, I will be in your child's precalculus class to observe the strategies being used by the teacher to help students reacquire the Algebra 2 skills/concepts.

Finally, another question of the research study is "does skipping one or more semesters between mathematics courses affect the student's achievement in the next course?" To answer this question, the score your child receives on the district summative test in precalculus in May/June will be compared to the score on the district summative test in Algebra 2.

Your child's participation in this study is important to the success of the study. However, if you prefer that your child not participate, simply have your child return the attached form to the guidance office at the school by January 20, 1997. If you would like to know the results of the research study, a summary of the results will be made available to you in the school media center by September, 1997.

All data will be held strictly confidential, and no names of school, teachers, or students will be given in the final report.

Thank you for your consideration of this request. Hopefully, the results of this study will be useful to those who make decisions about school schedules and to students and parents as they plan the high school course of study. I am happy to answer any questions you may have about the research study. I can be contacted at (301) 694-9407.

Sincerely,

Brenda P. Shockey, Doctoral Candidate
Educational Policy, Planning, and
Administration
University of Maryland, College Park,
Maryland

Dear Ms. Shockey:

I request that my child, ____________________, not participate in the research study in which he/she child will repeat the school district summative test for Algebra 2. This test will be given when my child begins the precalculus course at the beginning of the second semester and again approximately two-four weeks into the precalculus course.

Signed: ____________________________
(Parent/Guardian)

Appendix D

Observation Checklist

Observation Checklist

Strategies used by mathematics teachers during review for the reacquisition of skills/concepts.

Strategy Time Beginning Time Ending Total

Explanation
- review of objectives <--
- warm-up <--
- discussion of
  - -warm-up <--
  - -homework <--
- lecture/discussion <--
- 5 minute pause <--
- other <--

Application
- computer use <--
- problem solving <--
- interdisciplinary activity <--
- cooperative learning <--
- group work <--
- guided practice <--
- work on homework <--

Synthesis
- review of lesson/activity <--
- reteaching <--
- closure <--

Explanation: Involves identifying objectives, specifying tasks to be completed, demonstration of how to solve a particular math problem, lecture

Application: Students are assisted in applying what the teacher has been explaining; hands-on; may include computer time, cooperative learning activities, guided practice, independent practice

Synthesis: The teacher involves the students in connecting the explanation part of the lesson to the application phase; may include review and sometimes re-teaching or re-explaining, closure of the lesson

Design of checklist is an adaptation of the recommended strategies in Block scheduling: A catalyst for change in high schools (1995) Canady, R. L. & Rettig, M. D.

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